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A NOVEL METHOD OF ERECTING THE ROOF TRUSSES OF THE 71ST REGIMENT ARMORY, NEW YORK CITY.

By W. T. McCarthy.*

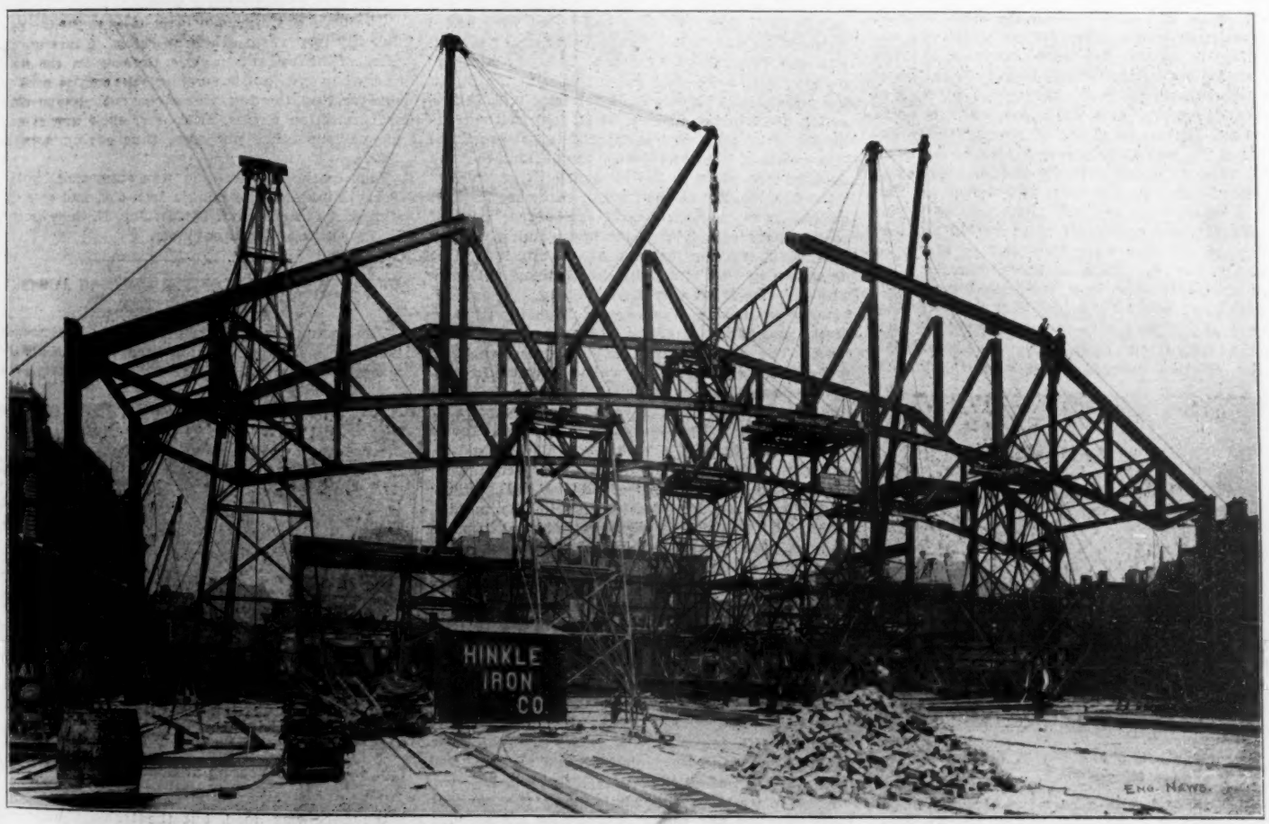
The main object of the present article is to describe an economical and, so far as the writer knows, a novel method of erecting a riveted truss of long span.

To begin with, it will perhaps be well to give a short outline of the reasons leading to the adoption of this form of truss, and a few words describing the structural work of the old building may prove interesting.

The Seventy-first Regiment Armory, National Guards, State of New York, was burned in 1902, and in wrecking the old building it was found that very little steel had been used in its construction, the framing, including the trusses, with the exception of the connecting pins, being of iron. The main roof trusses were about 190 ft. span, extending from 33d St. to 34th St., and carried the company rooms suspended from them near the ends, as shown in Fig. 1. They were of the Warren type, with the lower chord and diagonals of eye-bars, pin connected, and were supported at the ends by channel and plate columns, which were carried down only as far as the main, or drill room, floor, and rested on large brick piers extending from solid foundations in the basement up through two stories.

The drill floor itself was supported by three-hinged iron arches of 144-ft. span c. to c. of bearing pins, as shown in Fig. 2. Hinges were formed with 10-in. steel pins, those at the ends resting in heavy cast steel bases, as shown in Fig. 3, and those at the center as shown in Fig. 4. The tie was a 3 ft. box girder, with ⅝-in. web plates 16 ins. apart and 4-in. flange angles under basement floor, and in some places resting in trenches blasted in the rock, Fig. 5.

In the new building, now being erected, the mezzanine floor and drill floor, or 1st and 2d floors, are carried on cast-iron columns, while the large main tower and trusses are carried on plate and channel columns resting on rock footings in the basement and extending up through three stories to the point of connection with the trusses.



ERECTING THE ROOF TRUSSES FOR THE 71ST REGIMENT ARMORY, NEW YORK CITY.

The trusses now being erected were designed by the writer in the office of Clinton & Russell, New York City, architects of the new building, and are a modified type of Pratt truss, with curved lower chord as shown in Figs. 6 and 9. This form of truss was adopted primarily to keep a minimum unsupported height of columns with a maximum height under trusses from main floor, and, being in a conspicuous position, the aesthetic as well as the economic side of the question had

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to be considered, which led to the form used, as it was found on investigation that a riveted truss of this span would be more economical in material, as well as in erection, than any other form.

The trusses are connected to the columns on the 34th St. side of the building with a 7¾-in. steel pin, and with the gusset plate and curved knee brace, shown in Fig. 6, riveted fast to secure a rigid connection. Their opposite ends are supported by a pendulum joint with two 7¾-in. pins, as can be seen in large detail in Fig. 7. The curved

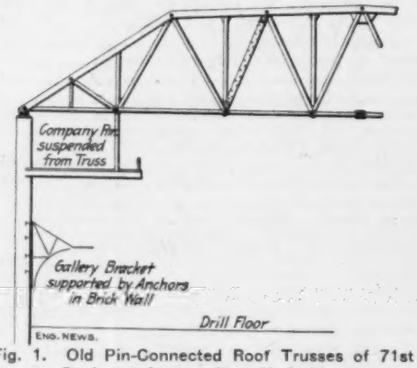


Fig. 1. Old Pin-Connected Roof Trusses of 71st Regiment Armory, New York City.

knee brace at this end is riveted to the truss only, the end next the column being free to play between two 6 by 6 in. angle guides on the column, to take up variations due to expansion and contraction, and merely completes the curve of the lower chord.

In erecting this sort of work the usual method is to erect a timber falsework on which the assembling is done, but this occupies a large amount of floor space which could be employed to better advantage, beside taking a long time to erect and remove, and when the work is completed the timbers in it are of comparatively little value. It was therefore decided that the work could be done more cheaply and quickly by a system of light steel towers and derricks. The truss columns were set, and the brick walls run up a short distance to give them lateral bracing. Two boom derricks were then put in place, as shown in Fig. 8. Each of these derricks consisted of a mast 80 ft. long, weighing 3 tons, with a 72-ft. boom weighing 2 tons and had a lifting capacity of 11.2 tons with boom horizontal. These derricks rested on light steel towers similar to the erection towers, about 20 ft. high with

Fig. 3. Steel Casting and Pin at Foot of Three-Hinged Arch.

a 14-ft. base, and with a carrying capacity of 2a tons. These towers were blocked up on the main floor framing, and, on account of the distance between corner posts, it was possible to distribute the load over four columns underneath.

Derrick No. 1 was placed so that the top of the columns at the 34th St. ends of trusses Nos. 1 and 2 (Fig. 8) could be reached with the end of boom. Derrick No. 2 was placed just south of the position to be occupied by tower B as located in Fig. 6, and in this position could hoist the steel from trucks in 33d St., hand it over to derrick No. 1, and two end sections of a truss could be assembled at the same time and in position for hoisting into place at opposite sides of the building.

The erecting towers were built of angles and channels (see Fig. 6 and front-page view) and were assembled on the floor previous to the delivery of the trusses. Their total cost was less than timber for false work would have been.

The upper and lower chord members of the trusses were delivered at the building in four sections or lengths each, with gusset plates attached. Two end sections of a truss, consisting of four panels each complete, were assembled with bolted connections flat on the floor directly under the position to be occupied by them. The pins and two toggle plates were then put in place in the top of the column and by means of derrick No. 2, Fig. 8, and a steel house derrick 60 ft. long with a capacity of 20 tons, one section of truss was lifted into position, connected with toggle and the end dropped into place in the column.

Derrick No. 2 was then freed, throwing its load on the house derrick which carried the part of section not carried by the column and with derrick No. 2, erection tower B was swung into place as shown in Fig. 6, and by dotted lines in Fig. 8. The end of section over tower B, Fig. 6, was then blocked up to the exact height from top of floor beams and guyed on either side to prevent turning over. The whole weight of the four panels of truss was then carried by wall column and tower B, the house derrick was swung over to the opposite side of the building and the corresponding section on that side was raised into place. Tower "A" was then placed (as shown in Figs. 6 and 8), and the remaining sections of lower chord were hoisted into position, bolted to the end sections and blocked to an exact height in the middle after which the web members were bolted in place and the two sections of upper chord put on, going into place without the slightest difficulty, due to having the lower member blocked and wedged to its proper position. Tower "A," Fig. 6, extends up directly beneath the upper chord where it is intended to remain until the whole roof construction is completed, acting as a brace while the trusses are being stiffened laterally by means of the purlin trusses, diagonal rods and concrete arch roof construction. Tower "C" (Fig. 6) is identical with tower "A," with the exception that the two top panels are omitted and will be used in the erection of all the trusses after No. 1.

After assembling the whole truss the connections in lower and upper chords over towers "B" were riveted. In the meantime end sections of truss No. 2 were being assembled in the manner just described, and when ready to be raised, the riveting of chord connections in truss No. 1 had been completed, the blocking removed from under these points, and towers "B" swung into position under truss No. 2, as shown by full lines (Fig. 8.).

The 18-in. I-beam purlins, framed between ends of trusses No. 1 and No. 2 were then put in place, then purlin trusses 1, 2, etc., Fig. 8. These were immediately followed up with the [illegible] I-beam rafters until the whole panel of [illegible] between trusses 1 and 2 was complete, with [illegible] exception of the space between purlins through which the derrick masts projected. The derricks were then lowered and moved to position between trusses 3 and 4, three changes of position being required to erect five trusses. These trusses are 190 ft. 4 ins. span from center to center of [illegible] (Fig. 6), weigh about 70 tons each, and are [illegible] erected

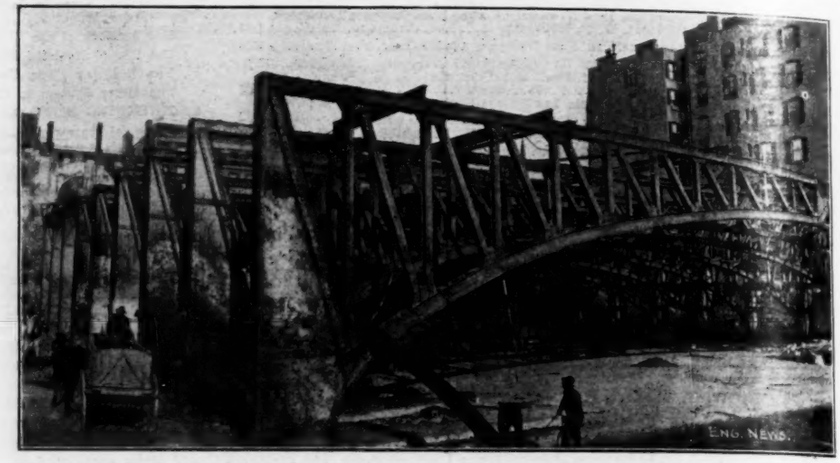


FIG. 2. OLD THREE-HINGED ARCHES CARRYING DRILL-FLOOR, 71ST REGIMENT ARMORY, NEW YORK CITY.

with roof framing complete by a force of 20 men at the rate of one truss a week.

The floor has not been blocked at any time sufficiently to prevent others working. There are no piles of heavy and useless timbers on the floor and when erection is complete the angles used in constructing the towers can be cut up and used as connection angles, stiffeners, shelf angles and for various other purposes, thus saving a great deal.

This method of erection was suggested by Mr. Terry Hinkle of the Hinkle Iron Co., and was designed and carried out by Mr. Jas. E. Geissberger, C. E., the company's engineer.

ANNUAL CONVENTION OF THE AMERICAN FOUNDRYMEN'S ASSOCIATION.

The annual convention of this association was held at Indianapolis, Ind., June 7, 8 and 9, the meetings being held at the Claypool Hotel. The

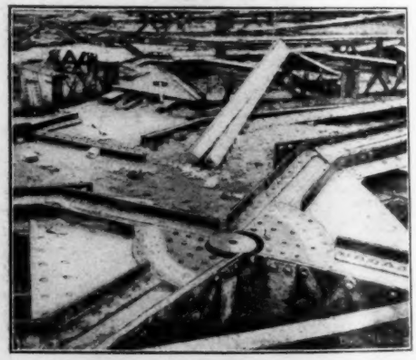


Fig. 4. Pin and Bearing at Center of Three-Hinged Arch.

attendance was good, but the technical proceedings were curtailed through the desire of many members to start for the St. Louis Exhibition, while one meeting was abandoned because practically all the members took part in an excursion intended specially for the ladies. The meetings were not called to order until a very late hour each day.

The first meeting was held in the afternoon of June 7, when addresses of welcome were delivered by the Mayor (Mr. Holtzman) and the Presi-

dent of the Commercial Club (Mr. Kern). The annual address was delivered by the President of the Association, Mr. Willis Brown (Erie, Pa.), in which he advocated a more extensive use of molding machines and other labor-saving machinery, and also a more systematic method of estimating the cost of work.

One foundryman will carefully determine the actual cost of getting out the material on a contract, and base his estimates on facts. Another one looks at the patterns or blue prints, scarcely reads the specifications, and guesses that it will classify with something that he has made before and underbids the actual facts, say, ½ ct. per lb. in castings, or $10 per ton on the pig iron. In like manner he reaches an estimate on the machine work from 10 to 20% below the facts. If he secures the contract he loses money. On the year's business he may cover these losses by more fortunate guesses, but it is a game of chance. He not only does his competitors an injury, but he injures himself. He sets up a false standard of costs, which must be met and overcome for months by the patient missionary work of those who do not guess at the cost of production. It is bad enough to deceive your fellow man, but it is worse to deceive yourself; worse for you. Can we get together and agree upon some suitable basis in figuring the costs of production and then let the quality of our work and the time in which it can be produced be largely the factors which win?

FIG. 5. SHOWING WRECKED ARCH AND PROJECTING END OF 3-FT. BOX GIRDER THAT SERVED AS A TIE.

The Secretary, Mr. R. Moldenke (New York), then read his report, which showed a membership of 278, as compared with 316 last year; it also showed a rather surprising lack of interest in the Association on the part of the foundrymen in general, due largely to the labor defense movement. The abandonment of the "Journal" of the Association was recommended. The report set forth the importance of the proposed standard specification for pig iron and castings, and advocated standard specifications for coke, as a large amount of coke from by-product ovens is now coming into use, and differs materially from the well-known Connellsville coke. Later on, in a paper on this subject, he suggested the following limits for coke: ash, 10%; sulphur, 1%; moisture, 1%. Reports of committees of some of the separate sections of the Association were then presented.

STANDARD SPECIFICATIONS FOR PIG IRON AND CASTINGS.

With the above preliminaries disposed of, the subject of specifications was taken up. The standard specifications for foundry pig iron, gray iron castings and malleable iron castings, as prepared by the American Society for Testing Materials, were submitted, and approved. In the specifications for pig iron, however, two changes were made: 1, for sampling, it was voted that one pig should be selected from each four tons of every carload, instead of each ten tons; 2, the clause relating to allowances and penalties was changed to give the purchaser the option of rejecting material that does not meet the specified chemical requirements. These two clauses, as modified, will read as follows:

Sampling.—In contracts where pig iron is sold by chemical analysis, each carload, or its equivalent, shall be considered as a unit. At least one pig shall be selected at random from each four tons of every carload, and so as to fairly represent it. Drillings shall be taken so as to fairly represent the fracture surface of each pig, and the sample analyzed shall consist of an equal quantity of drillings from each pig, well mixed and ground before analysis.

Allowances and Penalties.—In all contracts in the absence of a definite understanding to the contrary, a variation of .10% of silicon, either way and of 0.01% in sulphur above the standard is allowed. A deficiency of over .10% in the silicon, up to .2%, and a further increase in sulphur up to 0.01% over the above allowance gives the buyer the option of rejecting the shipment or of accepting it, subject to a penalty of 4% in the price for each element so affected.

Another paper presented was by Mr. Thomas D. West (Sharpsville, Pa.), on "Standard and Systematic Methods for Making Sand Beds." This was of a distinctly practical character, discussing various methods of making "soft beds" for open sand castings, and "hard beds" forming the bottoms of closed molds. A model was exhibited of a machine for testing the hardness of beds by a falling weight.

The evening session was not called to order until about 9 p. m., and the first business was the reading of a long paper by Mr. Geo. H. Hull (New York), on "The Pig Iron Warrant System as Applicable to the Foundry," which related rather to the commercial than the technical side of foundry work, more particularly in regard to advance contracts to secure a supply of pig iron at current prices. A paper on "Molding Machines and their Uses" was next read by Mr. E. H. Mumford (Philadelphia, Pa.), who suggested that the foundryman should have machines adapted to his work, and not be required to adapt his work to the machine. A short paper on "Moisture in Molding Sand" was read by Mr. W. S. Morehouse (New York), advocating especially the mixing of sands suitable for particular classes of work, in the same way that mixtures of pig iron are made:

Early last March a quantity of molding sand was received at our foundry, when the stock had to be replenished regardless of weather conditions. It looked as though it had come from a wet place, had been transported in wet weather, and in a leaky boat. Several samples were tested, and all contained about 18% water. It seems too bad to have to pay for much water at sand prices, and I therefore started an investigation.

The replies to my enquiries show that molding sand is generally purchased by the ton of 2,000 lbs., though occasionally the 2,240-lb. ton is used. Core sand is sometimes measured and 23 cu. ft. to one cu. yd. for a ton of 2,000 lbs. is used. The inference from the various replies would seem to be: Get sand in the dryest weather possible, and get enough to last until the next dry season. If you get caught short make the best possible bargain with your dealer, and do not be afraid to bear on, for he will meet you half way to hold your trade.

This is not satisfactory to the modern foundryman. It is far better to have definite standards to relieve the situation than to browbeat the dealer, or take the chance of being imposed upon by careless handling. An excess of 10 to 15% of moisture in a cargo of molding or core sand represents a sum that is big enough to be seen and to be an element in the cost accounts.

A long and detailed paper on "Cupola Fan Practice" was then read by Mr. W. H. Carrier (Buffalo, N. Y.), and gave rise to a rather animated discussion as to the melting ratio of cupolas, the ratio of coke consumed to iron produced. Some of the speakers declined to accept the statements of the paper in regard to high ratios obtained without further explanation of de-

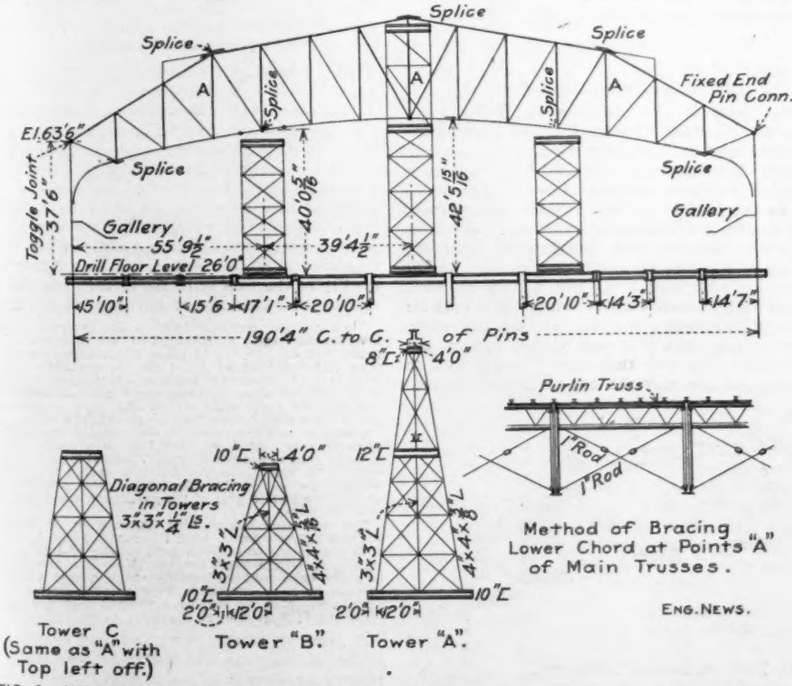


FIG. 6. NEW ROOF TRUSSES, 71ST REGIMENT ARMORY, AND METHOD OF ERECTION ON TOWERS.

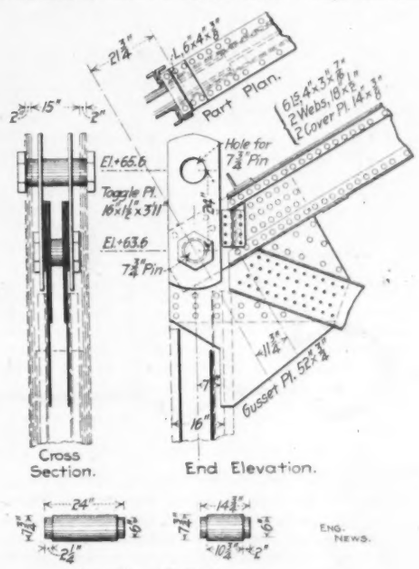


Fig. 7. Detail of Pendulum Expansion Joint at Free End of Roof Truss.

tails, and there was a dispute as to whether the bed should or should not be included with the charges in estimating the melting ratio. The author was inclined to think that it should not be included, but the more general opinion was that it should be so included. In the course of the discussion, Mr. T. D. West (Sharpsville, Pa.) spoke

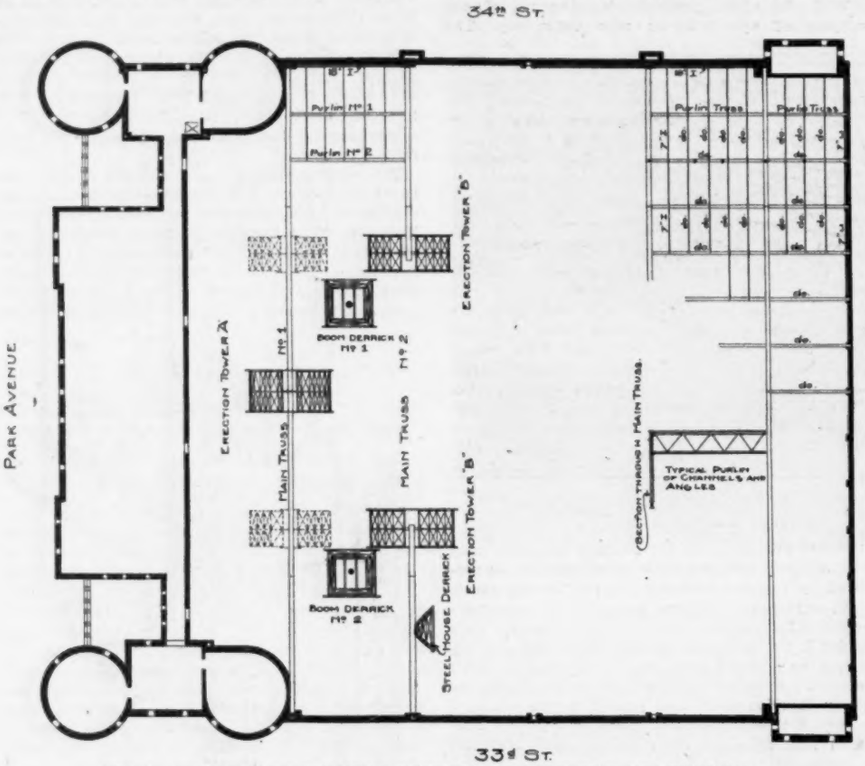


FIG. 8. FLOOR PLAN SHOWING POSITION OF DERRICKS AND TRUSSES.

of the central-blast cupola; but in answer to remarks as to the central tuyere being liable to become clogged up, he explained that this is about 4 or 6 ins. above the level of the side tuyeres, and as the slag is kept below these, the central tuyere opens into the clear metal.

The morning session of June 8 was not called to order until about 10.30, and was conducted by the Foundry Foremen's Section of the Association. Mr. Charles H. Thomas (Newark, N. J.), Chairman of the Section, presided. The first paper was by Mr. David Spencer (Chicago) on "The Needs of Modern Foundries," showing that the best work with highest economy can only be turned out in a well arranged, well equipped and well managed shop.

In building a modern foundry, the wisest thing the owners can do is to get a first-class foundry superintendent and have him assist in the drawing up of the plans.

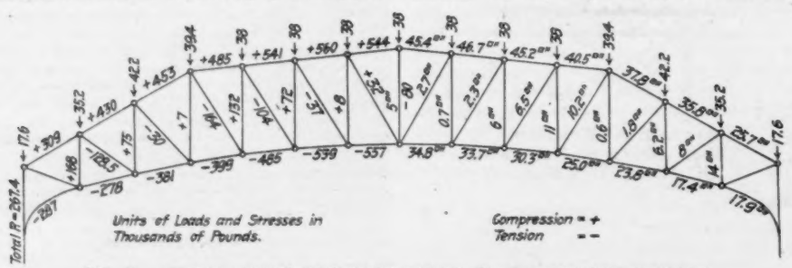


FIG. 9. STRAIN SHEET FOR MAIN TRUSS, 71ST REGIMENT ARMORY.

The buildings should be high enough to insure good ventilation, and give plenty of light. Good cranes should be provided, as well as core ovens, and a track running through the foundry, properly provided with turntables at each end and in front of the cupola. This track should extend out to the yard, so that large flasks can be loaded and run to their place with little help, instead of calling off all hands for the purpose, as is done in many places. There should be a cupola stage large enough to hold fuel and iron sufficient for three heats.

One member thought that good men should have been mentioned among the requisites for good foundry work. The molders are too often addicted to liquor, and drink while at work, and are consequently unreliable. In the foundry of the Enterprise Mfg. Co., at Philadelphia, drinking is not allowed during working hours, and men who do not work regularly are discharged. The speaker was a union man, and believed in the union, but thought that it made a great mistake in trying to force employers to keep men who do not and will not do their work.

FOUNDRY APPRENTICES.

Mr. Charles H. Thomas (Newark, N. J.) read a paper on the difficulty of getting and keeping apprentices, and of recruiting the army of molders. The city boy shuns all labor which involves exertion, and the trade must look rather to the country boy or the immigrant boy. In his own practice he instructs the apprentice personally, and does not allow him to seek information from the molder, or the molder to offer suggestions to the apprentice. He then gives him a piece of work and leaves him, until he gets "stuck" and asks for help. He then has the boy explain his work, shows him what was wrong, suggests ways out of the difficulty and then again leaves him to himself. In this way the boy is trained to heed instruction and to think for himself, making him self-reliant as well as capable. The union allows one apprentice for the shop and one to every eight molders, a ratio which was good years ago, but is unsatisfactory now. The foundrymen want an apprentice for every six men, but so far the union has refused to accede. The paper was followed by some discussion, showing the various difficulties of the problem.

Mr. B. I. Fuller (Allegheny, Pa.) read a paper on "The Core Bench," dealing with the best ways of making cores for different purposes and the special facilities required for this class of work.

SPECIFICATIONS, AND WHAT THEY MEAN TO THE FOUNDRYMAN.

This paper was by Mr. David Reid (Columbus, O.), and aimed to show that the foundryman often fails to give proper attention to the specifications governing work for which he takes a contract. On the other hand, too many specifications are merely based on a copy from others without regard to differences in requirements, owing to the fact that the engineer does not fully understand the metallurgical and practical conditions involved in the manufacture of castings.

If the foundryman has special requirements to meet he often passes them from his mind with the feeling that good commercial work will cover this or that right, only to have his credit and bank account impaired on account of his inability to carry out the specifications as agreed. The writer has had a number of instances of this kind drawn to his attention, and presents this matter with the idea of showing that specifications are being constantly drawn up, not for the purpose only of getting good commercial products, but to obtain something far superior to every-day castings.

The specifications for a No. 2 cast-iron for the Ordnance Department for a special contract I was engaged upon, are as follows: Material to contain silicon 1.25 to 1.35, sulphur not over 0.12, phosphorus not over 0.45, Manganese 0.65 to 0.75. Tensile strength, 30,000 to 35,000 lbs. per sq. in. Elongation before rupture, 0.25%.

To the credit of the American Foundrymen's Association and the Cast-Iron Committee of the American Society for Testing Materials be it said that we were in position to carry out such severe specifications, for their investigations have enabled us to specify in turn our pig irons in such a way that the furnaces could furnish just what was wanted.

Two classes of cast-iron specified while very similar as to strength, differ in that in the first case a charcoal iron melted in the air furnace (or a similar process giving the required elongation) is required; and in the second, the mixture of cast-iron and steel scrap, erroneously called semi-steel, is directly specified. Foundries heretofore making this No. 2 iron have always got the required strength by the use of steel scrap additions, but the general orders of last November from the Ordnance Department prohibited the use of this material, and compel the foundryman to stick to pig iron and scrap.

If great care is used this specification can be met, whether the air furnace or the cupola is used. I have had results which averaged 30,000 lbs. with greater elongation than required, by using charcoal irons with silicon 1.10, sulphur 0.065 to 0.075, phosphorus 0.30, manganese 1.15, and the total carbon from 3.00 to 3.50. The best scrap was used and ran about 1.65 in silicon. For the iron to meet the so-called semi-steel specifications we used a Southern iron in connection with the charcoal iron and 40% of clean steel scrap. The results were highly satisfactory.

At the morning session of June 9, Mr. T. T. Wilson (Detroit) presented a paper on

THE VALUE OF CHEMISTRY IN THE FOUNDRY.

This paper, which discussed the matter from the standpoint of the foundry foreman, showed that in order to produce first class castings it is first of all necessary to know for what purpose they are to be used, and then to prepare a suitable grade of iron by a mixture of different kinds of pig. The old way of preparing the mixture was largely guess work, being based mainly on the appearance of the broken pig as indicating the quality of the iron in it, the modern practice is to call in the assistance of scientific metallurgy.

We are buying our iron from several good and responsible furnaces, upon specification of the analysis for each grade wanted. In one of these which called for not less than 2.50% silicon we got 1.82. On another calling for 2.00 to 2.50 silicon we received one car with 1.37, another 2.90 and other elements varying just as badly. Had the mixture been made up by the physical appearance alone there would have been many castings ruined.

Chemical analysis used in conjunction with physical tests of bars cast from each heat is a sure method of keeping your castings uniform. Physical tests are reliable only in detecting trouble, but are unable to remedy it without the aid of the laboratory. Both are important, and should form a part of the practice in every well regulated foundry.

The coke used has a direct influence on the quality of the castings produced. With this running high in sulphur, it is impossible to make a good quality of light castings which can be machined readily. Here is a case in point: Our old coke contained 0.80% sulphur, and a new car ran up to 1.58, causing a very great difference in the shrinkage. Now we employ a chemist regularly and analyze the coke as well as the iron.

A paper on "Hard Iron" was read by Mr. H. E. Diller (Chicago), in which it was shown that phosphorus hardens iron to a slight degree, while silicon and sulphur tend to increase the hardness. With an excess of sulphur, hard spots will be found throughout the metal, which will interfere with drilling and planing. More important than the direct effect of these elements, however, is their tendency to affect the percentage of combined carbon. Investigations made of irons for casting radiators, with surfaces to be machined, showed it necessary to keep the combined carbon between 0.4 and 0.6%, and the total carbon below

3.50%. With combined carbon below 0.4% or the total carbon above 3.50%, the links would fail on the hydraulic test. With the combined carbon above 0.60% there was usually a complaint of hard iron, and when as high as 0.70 this was certain. In a series of such working tests it was found that putting high phosphorus irons in the mixture made it necessary to raise the silicon about 0.20% in order to get the same percentage of combined carbon in the castings.

A paper on "A Successful Piece Price System" was read by Mr. John Magee (Chelsea, Mass.), as representing the Foundry Accountants' Section of the Association. The last paper was on "Pattern-making in Relation to Foundry Costs," by Mr. W. H. Parry (Brooklyn, N. Y.), Secretary of the Pattern-making Section of the Association. The meeting then adjourned, and many of the members started at once for a trip to St. Louis.

The officers elected were as follows. President, C. J. Wolff, of Chicago; Secretary and Treasurer, Richard Moldenke, of New York.

MILE ROCK LIGHTHOUSE, SAN FRANCISCO BAY.

The National Government has advertised for bids for a lighthouse to be built upon a knob of rock about two miles west of the narrows of the Golden Gate. To be exact, Mile Rock is ½ mile inside a line joining the outer heads of San Francisco harbor, and ⅝ mile north of the nearest point of mainland. It rises nearly vertically out of the water, which is from 40 to 50 ft. deep, and affords just enough area to serve as a base upon which to build the proposed lighthouse, as shown in Fig. 1.

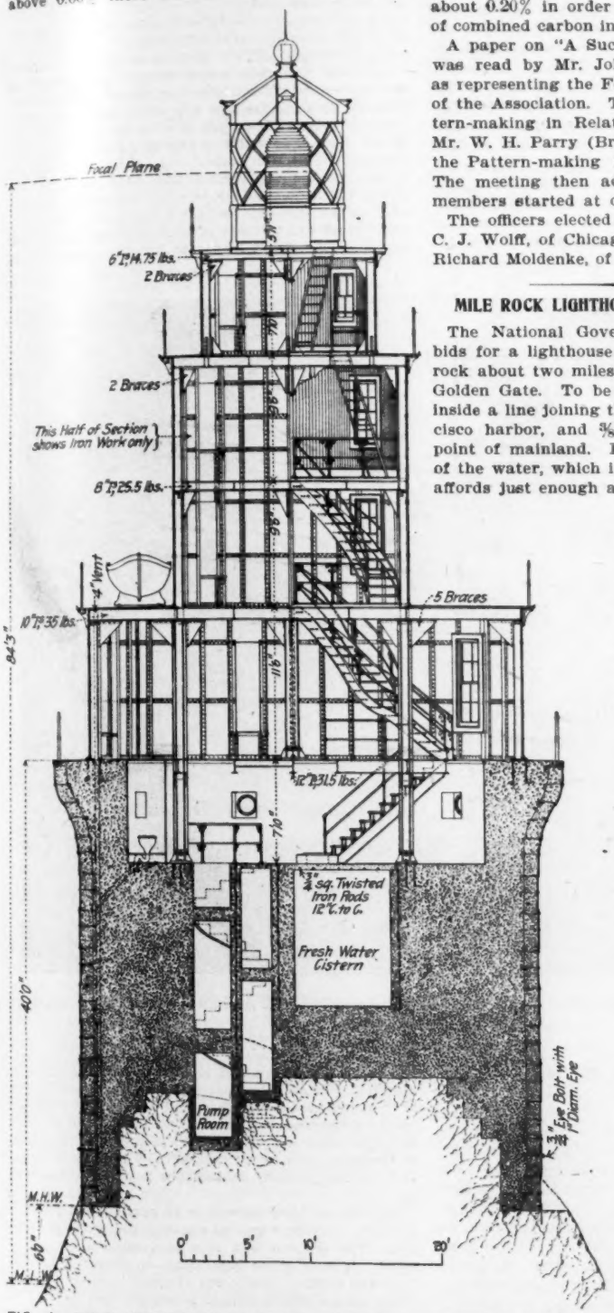


FIG. 1. MILE ROCK LIGHTHOUSE, SECTION ON LINE A-B, FIG. 2.

The mean rise and fall of the tide is about 6 ft., but, as the tidal current is very swift and the duration of slack water short, the difficulties of construction will not be slight.

As shown in Fig. 1, a structural steel tower is to be built upon a concrete foundation, the exterior of the superstructure as well as the concrete being completely encased with a steel shell. This shell will serve as an outer form for the concrete during construction, and as a permanent protection against impact. The tower will be four stories high, surmounted by a lantern, and will be used as a light and fog-signal station. It will be provided with a 25-ft. derrick boom for handling the boat and supplies. The power for operating the derrick and the 10-in. fog whistle will be supplied by two Hornsby-Akroyd 20-HP. oil engines, each operating an air compressor.

The top of the concrete base, upon which the tower will stand, will be 40 ft. above mean low water, and the focal plane of the light will be 84½ ft. above the same datum. The substructure will contain about 770 cu. yds. of 1-2-4 concrete.

The general design of the light house and its foundation are so well shown in Figs. 1 and 2 that further description is superfluous.

The plans and specifications for this work were prepared under the direction of Mr. Thomas H. Handbury, Lieutenant-Colonel, Corps of Engineers, U. S. A., Engineer of Twelfth Lighthouse District.

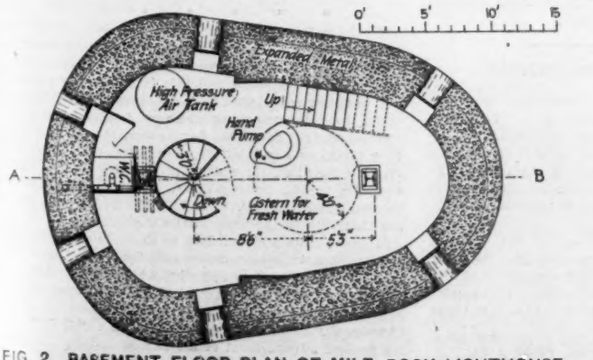


FIG. 2. BASEMENT FLOOR PLAN OF MILE ROCK LIGHTHOUSE.

SOME PHENOMENA OF THE ADHESION OF STEEL AND CONCRETE.*

By J. W. Schaub,† M. Am. Soc. C. E.

When a bar of iron is inserted in a fresh mortar of cement, the cement will at once attack the iron, provided the latter is free from dirt, oil or grease, and that all mill scale has been removed. If the mortar is allowed to set it will be found that a chemical combination has taken place between the surface of the metal and the cement. If the bar was bright, before coming in contact with the cement, it will be found dull in luster after the metal is exposed by removing the cement. The bar will, moreover, be found to have increased in weight, depending upon the length of time it has been inserted in the cement. M. Breuillie measured the increase in weight on thin plates, 2 × 2 ins., and found, after 76 days, an increase of about 12 milligrams in weight, depending upon the length of time the metal was exposed to the mortar.

If a soluble salt had formed, the plates taken out from the mortar should lose weight under the action of water This was found to be the case. After six hours the loss of weight was about 2 milligrams; and, after a second immersion of seven hours the loss was 2.2 milligrams. From an analysis of these plates the increase in weight appears to be due to the formation of silicate of iron.

If the bar had been rusty before inserting in the mortar it would have been found, at the end of 15 to 20 days, perfectly free from rust, so that it appears the iron has given up its oxygen to the cement. Moreover, the cement, being anhydrous and alkaline in its reaction, will prevent the formation of rust; so that a coating of cement mortar should be, from a chemical and physical standpoint, an absolute protection against rust. This property of cement is taken advantage of in Europe, and quite recently in this country, in using it as a coating on iron where exposed to gases and other destructive agencies. The mortar is usually a mixture of 1 cement and 2 sand, applied with a brush as a wash. Five or six coats are applied in this way to give the metal a proper coating. This is especially applicable in the case of the iron work exposed in roundhouses, where the gases from locomotives are so destructive, and where paint is so inefficient.

It has generally been assumed that concrete, when coated with a rich mixture of mortar, is impervious to water. In order to obtain definite information on this subject, M. Breuillie undertook a series of experiments, which are described in a recent issue of the "Annales des Ponts et Chaussees." Four slabs of reinforced Portland cement concrete were made, in which the proportions were as follows:

	1.	2.	3.	4.
Cement, lbs.	1,323	1,323	1,764	2,204
Sand, cu. ft.	12.6	12.6	12.6	12.6
Gravel, cu. ft.	31.8	31.8	31.8	31.8

All slabs were 36 × 39 × 11.8 ins. The steel consisted of 3-16-in. wires arranged as follows: About ¾-in. from the upper face there was placed a network of wires having a mesh about 1½ ins. square; this was followed by five other layers at intervals of 1½ ins., except that the third and fourth layers were 4 ins. apart. On top of the first layer a netting of 3-32-in. wire netting was laid, and the mortar was pressed on it so as to form a dense coating. Six manometer tubes were inserted in each slab, so that each layer of wire was reached by one tube for the purpose of recording the permeability of the concrete. The first slab was subjected to a pressure of 39.4 ft. of water in the morning, which was taken off in the evening. This operation was repeated for six consecutive days. The tubes showed that the water had penetrated the slab completely, and had reached the embedded steel. After this, the slab was left in the open air exposed to the weather, and from time to time pieces of the concrete were removed.

The edges of the slab were waterproofed by means of asphalt, so that water could not enter the slab except from the top. Upon removing the concrete, the metal was found in perfect condition, the mortar adhering to the metal near the edges of the slab protected with asphalt; whereas, in the interior of the slab, where the water was free to circulate, it did not adhere. In other words, the water had destroyed the bond between the mortar and the steel. The water was sampled before and after passing through the slab, and the analysis shows that the water just before passing into the slab, after removing the pressure, contained more cement salts than the water which passed through the slab.

The three remaining slabs were subjected to a water pressure of about 50 ft.; but, in spite of the rich mortar used, all three specimens being as dense as the best granite, the water penetrated all of them, after having been subjected to intermittent pressures. As before, when the slabs were broken, it was found that the mortar did not adhere to the metal in the concrete through which the water passed. It has been shown that a chemical union takes place between the iron and the cement, and it has also been shown that this union is dissolved in water, so that when it becomes necessary to rely upon this bond to preserve the integrity of any reinforced concrete struc-

*Extract from a lecture on "Reinforced Concrete" delivered at Armour Institute, Chicago.

†Consulting Engineer, Monadnock Block, Chicago, Ill.

ture, which is exposed to the action of water, it becomes necessary to make the concrete impervious to water.

The salt which is formed at the surface of the metal determines the amount of adhesion between the metal and the mortar. This adhesion depends directly upon the superficial area of metal exposed to the action of the mortar. In addition to this adhesion the concrete, when allowed to set in air, contracts violently and grips the metal, so that two distinct actions take place when any metal reinforcement is introduced in a mortar about to set. The one is chemical and takes place at the surface of the metal; the other is physical and is produced by the shrinkage of the concrete. These actions are entirely distinct and independent of each other, and one may take place without the other. For example, a wide thin plate may be coated all over with mortar, and obtain its greatest adhesion to the mortar, whereas, this same plate, when inserted in a mass of concrete may not be gripped at all by the shrinking concrete, owing to its peculiar cross-section. On the other hand, a bar may be painted before inserting it in a mass of concrete, so as to preclude the possibility of any chemical action, and still be gripped by the concrete. This has actually been done, strange as it may seem, on some important work. In other words, in order to obtain the greatest adhesion the metal should be wide and thin, and in order to obtain the greatest grip the cross-section of the metal should be either round or square.

In order to measure this adhesion, M. Breuillie prepared 30 plates 1⅝ × 2¾ ins., which he stuck on the top of a fresh bed of mortar of 1 cement to 2 sand. This was left to harden in a room under ordinary conditions. The plates were then lifted off in series, the first series after two days, the rest after five days. The tests were made so that only the adhesion was measured, and no friction or sliding could take place between the contiguous surfaces. The average results of each series were as follows:

Contract period, days.	Average adhesion, lbs. per sq. in.	Contract period, days.	Average adhesion, lbs. per sq. in.
2	4	17	16.2
7	9.5	22	18.5
12	13.5	27	18.8

The conclusions were that the adhesion increased uniformly and reached its greatest value after 30 days of 22 lbs. per sq. in.

It has been shown that water will destroy this adhesion. It can also be shown that heat will destroy it. If a bar of iron surrounded with concrete be subjected to a temperature above 1,000° F., the water of crystallization in the concrete will be driven off, and if this temperature reaches the metal the concrete will break off. This is an important consideration in the fireproofing of iron or steel with concrete, and is governed by the nature of the concrete and its thickness. This subject should receive investigation, as it played an important part in the late Baltimore fire.

The next consideration should be the grip of the metal due to the shrinkage of the concrete. This shrinkage takes place in all concrete allowed to set in air. If it is allowed to set in water the reverse of this takes place and the concrete expands. It follows that the metal inserted in the concrete must contract and expand with the concrete. In other words, the metal will receive an initial stress.

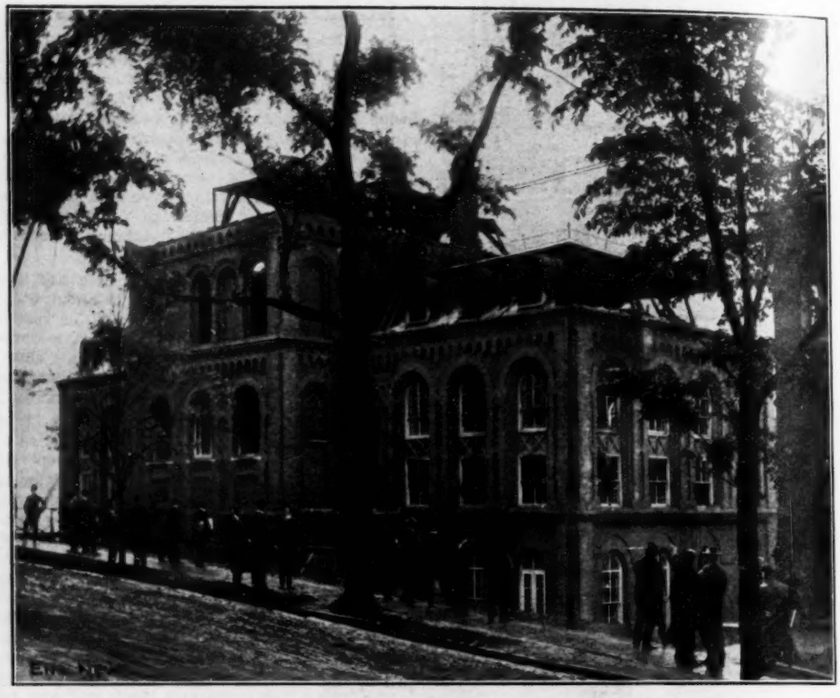
THE FIRE AT THE RENSSELAER POLYTECHNIC INSTITUTE.

By Prof. Wm. G. Raymond.

Early in the morning of Thursday, June 9, the Main Building of the Rensselaer Polytechnic Institute was practically destroyed by fire. The walls still stand, but the upper portions are so damaged as to be considered unsafe. With the exception of a small amount of floor space in the south wing, practically the entire building was gutted. The cause of the fire is unknown; and because no other reason can be assigned it is supposed to have been of incendiary origin. The extent of the loss to the institute has been estimated by Mr. James H. Caldwell, class of 1886, Treasurer, to be $100,000. The insurance is $48,000, $30,000 on the building, and $18,000 on the equipment contained in it. The floor in President Rickett's recitation room still stands, and a few of the many models contained in this room may be saved; but the majority are destroyed or ruined for the purpose for which they have been used. The very large collection of surveying instruments of all descriptions is practically wholly destroyed. There were but few books in the building except the library of Professor Raymond, which was but little damaged. The many pictures, charts and models used in instruction were destroyed, as were almost all of the memorial windows, among those gone being that containing the beautiful portrait of Amos Eaton, the first Senior Professor. The building burned was erected in 1863 and 1864; was first occupied in 1864, and has therefore been in use about forty years. About five weeks prior to the burning of the Main Building, the Chemical Laboratory was seriously damaged by fire for the second time within two years. The fire in the Main Building occurred two days before the completion of examinations for this year. Examinations were, however, continued in the other buildings of the institute and in the Troy Public High School, and have been completed. The exercises of commencement week will go on as already planned.

At a meeting of the Board of Trustees held June 13, a resolution was adopted appointing a committee of five to outline a plan for the construction of adequate buildings on a suitable site to provide for the present and the future requirements of the institute, and to report to the board at a future meeting.

Immediate steps will be taken to secure temporary quarters for the coming year, as it will be impossible to get permanent buildings ready by fall. As there were no laboratories in the burned building, it will not be a difficult matter to secure and temporarily fit up necessary rooms for lecture and recitation work. The institute will therefore be prepared to receive and will expect its usual class in the fall. In the meantime a concerted effort will be made to secure an adequate fund for building and for endowment. Already unsought subscriptions have begun to come in from citizens of Troy and alumni at a distance.



THE MAIN BUILDING OF RENSSELAER POLYTECHNIC INSTITUTE AFTER THE FIRE OF JUNE 9.
(From a photograph by Irish, of Troy.)

THE CIVIL ENGINEERING PROFESSION.*

By J. Foster Crowell, M. Am. Soc. C. E.

A profession is what its members make it. Your profession can be maintained and elevated higher and higher and made enduring for the life of the world.—Or it can be lowered and trailed in the dust and in the mire. The highest professional object of every engineer should be the profession itself and all that tends to ennoble it, in principle and deed and perfect work.

There has been a marked tendency of late, in this seething, strenuous land of ours, to extol the so-called "practical" man and some quite noted exponents of the type have been hastening about, explaining the superior advantages of a limited education, while the current mag-

*Extracts from an address before the graduating class of the Rensselaer Polytechnic Institute on June 15.

azines, as you know, have been filled with p[illegible] of so-called "Captains of Industry" who were s[illegible] have roached their well-deserved positions of great [illegible]inence chiefly because they had been untrammelled by [illegible]eading knowledge from books.

We in the profession have been hearing [illegible]ll our lives the superior merits of the practical [illegible]nd I suppose the song will still be heard as a lull[illegible] ignorance when the whole unbounded universe [illegible]nverted up; but let me tell you, for your comfort, t[illegible] most practical men are the best educated and th[illegible] really practical engineer is the one who has the th[illegible]l right at the start. Afterwards, a man may find [illegible] in experience and little in books," but you may [illegible]well assured that the fundamental knowledge you [illegible]ve acquired will not stand in your way. Yet, aim [illegible] practical to the uttermost, in your methods and [illegible]ery result. There is a tendency to be resisted that [illegible] young engineer feels,—the tendency to too great re[illegible]ment in results of calculations and to superfluous elaborations of processes. In such respects especially you should be on your guard against the charge of being unpractical, always remembering that it is not worth while, or sensible, to try to refine a result beyond the degree of refinement of the data. The young engineer also is prone to forget that for his purposes mathematics is a tool and not an art.

Not only will you do well to be practical but you will find that it is important to cultivate the executive function. The engineer who is a good executive is in demand. It is of prime importance, of course, to be able to design work correctly; but carrying it out in the best and most economical manner is scarcely less so. Study, therefore, to build up a reputation as a good executive, as well as a good designer.

* * * * * * *

We have been speaking among ourselves of the engineer's profession as if it were one that is thoroughly well defined and of accepted meaning. Such, however, strange to say, is not the case and this is all the more surprising when we reflect that in the modern economic development the community has come to depend on the engineer absolutely and from day to day, for its very existence almost and certainly for its comfort and convenience. Its food supplies, its water, its fuel and light, its business, its trades, its commerce, its manufacture, its intercommunication,—all, in fact, of its physical activities, are bound up in the work of the engineer.

In Great Britain the modern engineer came to the front earlier than in this country and the people know him better for what he does and what he is. But at first they did not. In 1818 was established the Institution of Civil Engineers, and in 1828 it was incorporated by Royal Charter, the language of which states its object as "being the general advancement of mechanical science, and more

particularly for promoting the acquisition of that species of knowledge which constitutes the profession of the civil engineer." To which were afterwards added upon the diplomas of the institution the significant words of Thomas Tredgold as an amplification, to wit, "being the art of directing the great sources of power in nature for the use and convenience of man." Thus showing that the public had to be educated up to us, even in England.

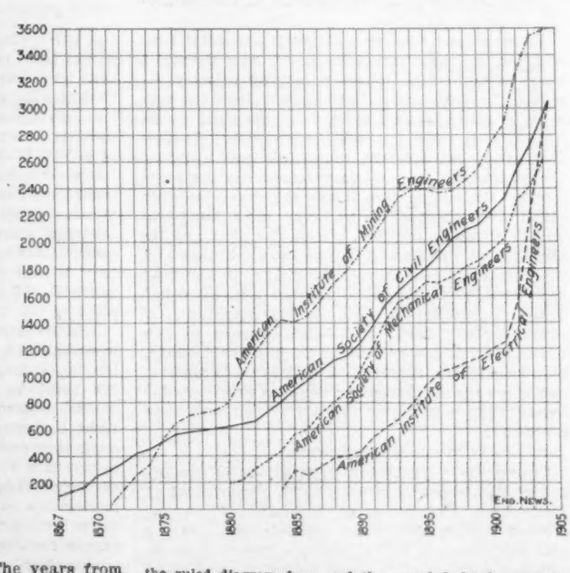
It is very interesting to note that at the time this definition of the civil engineer was coined, the age of steam had scarcely begun and the existence of electricity as a source of power for engineers to deal with was not suspected.

It was not until a quarter of a century later, in 1853, that the American Society of Civil Engineers was formed; and that body seems to have taken for granted that a professional definition was no longer necessary. That perhaps was unfortunate, for had it been otherwise, the present confusion in the public mind in America as to what particular kind of an engineer a civil engineer is, might not exist. The present constitution of this society goes to the other extreme in providing that "A member shall be a civil, military, naval, mining, mechanical, electrical, or other professional engineer, an architect or a marine architect." From the strictly professional point of view such segregations tend to destroy and not to upbuild. In practice, however, it cannot be said that this society, grouped as it is nominally, has not built up the profession in this country. Still the results fall short in solidarity of what is really needed to elevate it commensurately with the importance of the part it plays in the body politic.

With this end in view we should ever maintain that there is but one wide field of civil engineering which embraces all engineering excepting that which may relate exclusively to the art of war. There are many branches and countless specialties but there should be, and logically there is, but one profession of the civil engineer.

THE GROWTH OF THE FOUR NATIONAL ENGINEERING SOCIETIES.

The accompanying diagram is redrawn from one issued in June bulletin of the American Institute of Electrical Engineers. The reason for its appearance there is doubtless because it depicts so strikingly the marvelously rapid growth of that Society during the past three years. From a membership of about 1,250 in 1901, it has grown to a membership of over 3,000 at the present time. It is fair to point out that these figures represent in each society the total membership in all grades, and that in the Institute of Electrical Engineers the bulk of the members are in the lowest grade, that of Associate, for which no qualifications in the way of technical training or experience are required. Notwithstanding this, the increase in membership is a most remarkable one, and strongly attests the popularity of the system of local meetings and branch organizations which the Institute has adopted. We may add that a large proportion of these new additions to the membership are recent graduates of engineering schools who will make desirable additions to the higher grade of membership in after years as they gain in experience.



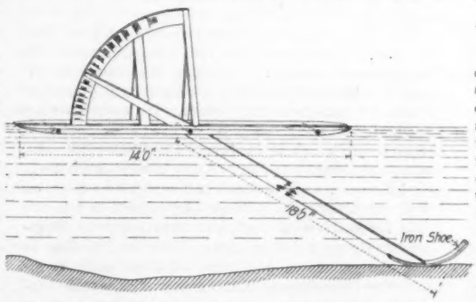
Concerning the growth of the other societies, a very noticeable feature is that past periods of financial depression or prosperity are plainly evident on the diagram. The years from 1876 to 1880 show very little increase in the two societies then existing. The depression from 1893 to 1898 also left a very plain mark on the lines of the mechanical and mining engineers, and is noticeable in lesser degree on both the civil and the electrical engineers, although it is obscured by other modifying causes.

Still another interesting feature is the fact that all the Societies can reach their days of small things without looking far back. Going back only a score of years, the Civil Engineers had only eight or nine hundred members, the Mechanical Engineers had half as many, and the Electrical Engineers were only just organized with about 150 members.

A RAPID METHOD OF TAKING SOUNDINGS IN SHALLOW WATER.

The accompanying sketch illustrates a system of taking rapid soundings which has been used on the River Yare, at Norwich, England, having been devised by Mr. Arthur E. Collins, Engineer to the River Yare Commissioners. The operation of the device is described by its inventor in a recent issue of the English magazine, "Public Works," as follows:

It consists of a raft supporting a sounding batten, provided with a pivot where it passes through the raft. There is a weight at the lower end of the batten to keep that end submerged. The upper end acts as a finger and indicates on a circular arc the depth of water on which



A Device for Taking Soundings in Shallow Water.

the apparatus is floating. The sounder is towed alongside a steam launch. The surveyor sits at a table in the launch and is provided with a sheet of cross-section paper on which the vertical lines refer to positions along the river banks which are indicated by corresponding numbers in a plan lying before the surveyor. The horizontal rulings refer to depths below ordnance datum or heights above. As the launch proceeds along the river at a known speed, the surveyor marks the depths indicated by the sounder at the proper points on the section to correspond with his position along the river; these depths are below the water line at the instant of taking the observations without reference to the height of water line relatively to ordnance datum. At intervals of about two miles tide gages are fixed at the river banks, the zero on each of which is ordnance datum; as the launch passes each tide gage the water level above or below ordnance is noted.

When the surveyor has finished sounding for the day, the water level as read from the tide gages is drawn on the ruled diagram form and the sounded depths as indicated on the section used on the launch are transferred from depths below the water line at the instant of taking the observations to depths below corrected water level relatively to ordnance datum. With the slight tidal range in the Yare it is found that the variations due to rise and fall of tide during the time occupied by the launch in passing from gage to gage are negligible. It will be seen that the author's system of observing and recording soundings is one which admits of very rapid execution, in fact two sections of the whole length of the river between Norwich and Yarmouth Bridge (a distance of about 30 miles) have been taken and recorded in two days.

It will be seen that the instrument shown is designed for use in rather shallow water, as the surveys are being made with a view to deepening the Yare to provide a 15-ft. channel for shipping.

A very similar device, designed by Mr. R. M. Pardessus, of New London, Conn., and used for sounding dredged areas in the harbor at that city, was described in Engineering News of June 18, 1903. The New London machine was provided with a recording device on the raft or scow, where a pencil attached to the inclined sounding arm marked its position on a moving strip of paper, thus giving a continuous profile of the bottom, along the range over which the sounding-scow was being towed.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the derailment of a north-bound through passenger train on the Southern Ry., near Salisbury, N. C., on June 9, 1904. Two trainmen were killed.

AN EXCURSION STEAMER, the "General Slocum," caught fire in the East River opposite 138th St., New York City, on June 15 while crowded with a Sunday school excursion party numbering about 2,000. The boat was run ashore on North Brother Island, but burned so rapidly that many of the passengers were burned to death. Of those who threw themselves into the water many were drowned before they could be rescued. No estimates of the loss of life are possible at the time we go to press, except that the number will probably reach several hundred.

A SEWER EXPLOSION occurred at Chicago on June 11, killing four men and injuring three. The explosion occurred at the Halsted St. end of the 39th St. intercepting sewer or conduit, wrecking the temporary pumping plant. The sewer is 20 ft. diameter, and was built under two contracts, a bulkhead being put up between the two sections. It has been finished and unused for some time, except that the west end received sewage which was raised and pumped into the river by a temporary plant. On the recent completion of the South Side intercepting sewer system, for which the 39th St. conduit will be the outfall to the river, instructions were given to have the conduit cleared out. About 10 a. m., Mr. Guy Miltimore, Assistant Engineer, with three men, descended the shaft, the engineer carrying a gasoline torch. The explosion followed at about the time the party reached the tunnel. Mr. Miltimore and the three men with him were killed outright; manholes were blown off for considerable distances, and at one manhole flames leaped out so fiercely as to set fire to a house. Sewer gas is claimed as the cause of the disaster.

AN ELEVEN-STORY WAREHOUSE in Peoria, Ill., collapsed without warning on June 4, 1904. The warehouse, 11 stories high, belonged to the distillery of Corning & Co., and in collapsing it fell over on the adjoining part of the distillery. A large amount of spirits was set free in the collapse and soon caught fire; the burning spirits set fire to some large cattle sheds lying between the warehouse and the Illinois River, and several thousand cattle were burned to death. A number of workmen were killed in the collapse of the warehouse.

THE WATER POWER of the Chicago Drainage Canal is desired by the city of Chicago for operating street lighting plants, at a rental which would be the actual cost of producing the power. The Sanitary District, however, wishes to sell the power at higher rates to towns along the line of the canal, but negotiations are in progress between the city and canal authorities. The following figures are from a statement prepared by Mr. E. B. Ellicott, City Electrician:

Three engineers have figured upon the anticipated cost of this power, and they agree that it will approximate $10.25 per HP. That estimate includes the generation of the power, the expense of bringing it to Chicago, the depreciation, the maintenance and 4% interest on the investment. We are now using in the streets 5,080 arc lights, which we operate ourselves at an annual cost of $54.50 a light. We also rent 674 arc lights for which we pay $103 a year apiece. Of the annual outlay of $54.50 for every city arc light, $29 represents the cost of generating that light by steam, while $25.50 is the electrical expense. The latter expense would remain the same in any case, but the $29 is the item which by the use of the power from the sanitary canal at cost we could reduce to $10.25. The 5,754 arc lights now in the streets of Chicago could be increased to 16,000 if we had the canal power at cost.

THE WISCONSIN STATE CAPITOL BUILDING, which was partly destroyed by fire recently, is to be rebuilt and a limited architectural competition has been arranged in which the following architects will take part: Cass Gilbert, New York; Ferry & Clas, Milwaukee; H. C. Koch & Co., Milwaukee. Each competitor is to receive $300 toward his expenses and prizes of $2,000, $1,500 and $1,000 are also provided, besides which the author of the best plan will be appointed architect of the building. The competitors will have until Nov. 1 next to complete their plans.

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Most of our readers will recall the much advertised series of tests of high-speed electric cars made a year ago on the German military railroad between Marienfelde and Zossen. The same piece of track has been used this spring for trial high-speed runs of steam locomotives and some of the results are set forth in a recent report of U. S. Consul-General Mason, of Berlin.

In the electric railway tests a single motor car was run at speeds which attained a maximum of 117.32 miles per hour. In the steam railway tests no such high speed was attained, one very good reason among others being that the locomotive was given a fair-sized train to haul. It was operated first with a train of six vestibuled cars weighing about 30 tons each and later with three such cars. The results of tests with four different locomotives are described in the report and it appears that with the three-car train the speeds attained varied from 76.42 to 85.12 miles per hour While it is not definitely stated whether this was the average speed over a given distance or the maximum rate of speed reached, all the probabilities point to the latter as the correct interpretation.

Assuming this to be the case, the first comment to be made is that such a speed record is not by any means startling to engineers familiar with American railway practice. Speeds approaching 80 miles an hour and upward are attained almost every day in this country, it is probable, on some parts of the run of the Empire State Express or the fast trains to Atlantic City from Philadelphia, and are reached moreover with trains weighing considerably more than 90 tons. As we have previously pointed out, American locomotive designers can build locomotives to run at higher speeds than are now run, whenever the public is willing to pay the cost of such high speed service. So far the percentage of travelers willing to pay a large increase in fare to ride at 60 miles an hour instead of 40 miles has never been found to be considerable.

One feature of these German tests of considerable interest is that the two highest records—84.5 and 85.12 miles per hour—were made by two locomotives of radically different construction One was a locomotive not built specially for the tests at all but one of a number in regular use on the Prussian State railways. It has only 963 sq. ft. of heating surface, but the steam is superheated by a Schmidt superheater of 288 sq. ft. The other machine was in every respect a contrast to the one first described. It was built especially to obtain high speed, has 2,766 sq. ft. of heating surface, is of the four-cylinder compound type with the reciprocating parts counterbalanced and weighs nearly 77 tons without the tender.

Yet this huge machine, built especially for high speed, eclipsed its much smaller rival from the regular railway service by a fraction too small to be worth mention. It is fair to add that had the test been on a run hundreds of miles in length, the value of the huge boiler of the second locomotive would doubtless have been evident and the relative showing of the two locomotives would doubtless have been very different.

The large machine above referred to has since the tests been dismantled and shipped to the St. Louis Exposition by its builders, the Henschel Locomotive Works of Cassel, where it will doubtless be seen by many of our readers. Its most striking peculiarity to the average observer is the fact that the engineer's cab is in front, over the pilot, and not in the usual position. This is not an entirely novel feature, as a similar cab was to be seen on the Creusot high-speed locomotive exhibited in the Paris Exposition of 1900 and illustrated in Engineering News at that time. We would like to raise the question, however, whether such a location for the engineer's cab is not well worth consideration for use on locomotives which are to haul our fastest express trains, those scheduled at 60 miles an hour or upward. There is a certain advantage in having an entirely clear outlook ahead without interference from the locomotive boiler and its projecting parts or with the steam escaping here and there. May it not be possible that this advantage is a good deal more important than those who design locomotives and those who erect signals now realize? Present practice may be all right for trains of moderate speed, where the engineer has plenty of time to make his signals; but for the trains of highest speed where the engineer has but a few seconds to read a signal and a puff of steam just at that moment may obscure it—on such trains this plan of placing the engineer's cab at the front of the locomotive deserves attention.

Many of our readers will recall the fatal rear collision on the Central R. R. of New Jersey a year or more ago, where a leaking injector diverted the attention of the engineer from the signals, or else obscured them from his sight as he flashed past them. It will be remembered, also, that after that accident, much talk was heard of the compulsory use of two engineers on the locomotive. In our opinion if two engineers are ever placed on high speed locomotives, the thing to do will be to place one in a cab on the pilot and let him observe signals and handle the air brakes and the throttle, while the second runner in the rear cab attends to the boiler feeding and all other duties in connection with the big machine. Of course it will mean additional expense to run trains in such a way, but as we have said above, high-speed train service is bound to be expensive, and if we cannot afford the expense necessary for safety, then it is better to stick to ordinary time schedules.

Among the forthcoming publications of the office of Experiment Stations, U. S. Department of Agriculture, announcement is made of an important bulletin describing methods of preparing land for irrigation and applying water to crops in different sections of the arid region of the United States. In this bulletin the methods of getting rid of sagebrush, smoothing the ground, building laterals, and distributing water over fields as developed by the experience of farmers in irrigated districts, are brought together and described. The tools and implements used are illustrated and the cost of the work, based upon actual examples in different States, is given. The purpose is to afford beginners a reliable guide both as to the cost of bringing wild land under cultivation and methods best suited to different soils, climates, and crops. The facts included in this bulletin have been gathered by the Irrigation Investigations of the office named above, acting in co-operation with the state experiment stations and state engineers' offices.

The bulletin brings out the fact, not well understood, that the cost of preparing land for irrigation is in many instances greater than the cost of building canals and reservoirs. Detailed figures of the cost of checking land show that it varies in certain districts in California from $6.00 to $18.08 per acre. This, it is stated, is more than twice the cost of the canal systems in the San Joaquin Valley, California, which is given in the report of the Census Bureau for 1902 as $4.99 per irrigated acre. Where the preparing of land is contracted for, the cost of checking varies from $7.50 to $20 per acre. The price of preparing land for flooding is much less, but is $5 per acre in Wyoming. It is pointed out that the need of a better understanding of this particular branch of irrigation practice is becoming more and more important. Reservoirs and canals are but means to accomplish a purpose. That purpose is to increase the products of the soil. The value of the ditch or reservoir depends upon the acreage of land which it will serve and the increase in the value of the products which the use of water will bring about. The time is coming when the most important problems connected with irrigation will be the best means of applying water and not, as at present, those of canal and reservoir building.

About thirty different methods of applying water are now in use. This does not mean that there are thirty distinct systems, but indicates the different ways of preparing land by checking, compartments, deep and shallow furrows, flooding, sprinkling, and sub-irrigation. The bulletin gives some of the results of a series of tests of different methods of applying water and the difference in loss of water by evaporation in deep and shallow furrows and in flooding. About 1½ times as much water was needed to irrigate an acre of land by flooding as was required in furrows 12 ins. deep. About 1 1-3 times as much water was needed to irrigate in furrows 3 ins. deep as in furrows 1 ft. deep. A saving of one-third of the water by the adoption of a better system would mean not only increased profits to farmers, but a large increase in the acreage which could be irrigated from canals or reservoirs.

A correspondent, commenting upon the editorial in our issue of May 5, wishes the fact emphasized that railroads will find no "scarcity of engineers" if they will pay salaries of $2,000 to $5,000 a year. Our correspondent says: "Quite naturally the scarcity of engineers is very marked—for salaries of $75 to $125 per month."

Our editorial was intended to point out to young engineers that the best field, for engineers desiring to earn large salaries, is at present in lines of business where an engineering training can be used to advantage. That this is a fact is due in part to the comparatively low salaries paid by railroad and other companies to engineers in their employ.

Another correspondent asks this question: "Are not engineers themselves in part responsible for the low salaries paid to engineers?" To illustrate his point he calls attention to a large public works contract where the chief engineer has the right to increase or decrease the salaries of the engineers under him. But this chief engineer, apparently for the purpose of keeping the cost of engineering and inspection below 3 or 4%, is paying his assistants just as little as they will work for. There does indeed seem to be good reason for complaint when a chief engineer buys engineering service in the cheapest possible market. The worst of this practice, however, lies in the fact that it results in driving many of the most ambitious young engineers into other lines of work. For a while it may be possible to hold able men on small salaries, and the chief engineer may flatter himself at his own astuteness, but sooner or later the best of his force will leave him, one at a time, as better openings present themselves. Young engineers may accept hod carriers' wages for a time, but the time will be shortened in proportion to their ability and ambition.

The alterations in the plans of the new Croton dam, or Cornell dam, for the water supply of New York City were discussed at some length in

this journal at the time they were made, two years ago. In the present issue we give space to a paper by Mr. Wm. R. Hill, the Chief Engineer on whom the main responsibility for the change of plan rested, summarizing briefly the reasons why the change was made.

We do not propose at this time to raise anew the general questions as to the necessity for the changes made under Mr. Hill's direction. That is a matter on which engineers will probably have to "agree to disagree." One matter brought forward by Mr. Hill does seem to call for comment, however, since it relates to the general design of earth dams. We refer to the statement several times repeated, that an artificial embankment is less solid, less permeable and less reliable than a natural deposit of earth. Thus Mr. Hill says:

> This embankment was hazardous because of the unstable nature of its foundation. It was founded over a great refilled pit, which was 300 ft. wide at the top, 170 ft. at the base and 70 ft. deep. It would be impossible to refill this pit as compactly as original ground, hence the safety of the reservoir was dependent not only on an embankment of a problematic section, but this problematic section rested upon an unstable foundation.
>
> The water would be afforded freer access through the refilled material of the great pit than it would have in ordinary cases where the wall below the original surface of the ground is in a narrow trench and protected by original soil.
>
> A fourth objection might here be stated, namely, the permeable and light character of the earth of which the embankment was made, but even with the best of material, an embankment so constructed would be insecure.

Now the usual rule is exactly the reverse of that stated by Mr. Hill. An artificially made embankment puddled and rolled in the manner adopted for the construction of earth dams or reservoir embankment contains almost invariably a greater amount of material per cubic foot and is less pervious to water than the same soil in its original position. Thus in the construction of an earth dam where the site is covered by a layer of earth or other material, let us say 50 ft. in depth to the rock, it is better and safer to excavate to the rock and refill the material again than to build the dam on the original surface of the ground. Whether local conditions existed at the Croton dam to alter this general rule we cannot say; but we call attention to the matter here since it relates to the general design of earth dams and if left without comment might mislead some young engineer.

ROCK DUST AS A CAUSE OF PULMONARY CONSUMPTION.

An interesting paper on Miner's Phthisis was read on May 19 before the Institution of Mining and Metallurgy in London, and is reprinted substantially in full in this issue. The authors of the paper, Dr. J. S. Haldane and Mr. R. A. Thomas, have been engaged in an elaborate investigation to ascertain the cause of the prevalence of phthisis among the miners of Cornwall. It has been supposed that the exposure to high temperatures underground and to sudden changes in temperature on coming out of the mine, often in damp clothes, accounted for the prevalence of lung disease among miners. The climbing of long ladders, living in unsanitary tenements, and breathing gaseous impurities underground are among the other causes which have been supposed to produce the disease and explain the high percentage of deaths from it among the miners. All these have been investigated by the authors of the paper, and it has been fully proved that they do not account for the prevalence of phthisis. The actual cause has been found to be the inhalation of stone dust. Investigations showed that the men working rock drills and most subject to dust, were by far the most frequent sufferers from phthisis. The inhalation of soft material, such as soot, coal dust or even iron ore dust, appears to cause no noticeable tendency to lung disease; but the inhalation of dust of a gritty nature, from stone or other hard material, is very serious in its effect. The disease does not usually develop until the victim has been exposed for years to the influence of stone dust; and this is the reason, doubtless, why the injurious effect of stone dust has been generally overlooked.

In the investigations it was found that a great increase in the mortality among Cornish miners has taken place during the last few years, and it appears that this increase is coincident with the general introduction of rock drills, which produce a great amount of dust, since the increased mortality appears to be almost wholly among the men engaged in working drills.

If the results of this investigation are trustworthy, and they appear to be entirely so, mining men, contractors and others engaged in work where stone dust is produced, ought to take prompt steps to remove the stone dust from the air breathed by their workmen. Such action is dictated not only by motives of humanity, but by business considerations as well. Take, for example, the driving of rock tunnels. There is every reason to believe that the rate of progress of the work will be materially increased by any method that results in giving the men purer air to breathe. This will follow not only because of the increased energy of the men due to better health, but because the dust which fills the heading after a blast is set off prevents the immediate return of the men to work, and thus causes a direct loss of time. Taking railway tunnel work as an example, the delays following blasting are such that several hours out of the 24 are entirely lost, as work is ordinarily conducted in the United States.

The Simplon tunnel is a striking example of what can be done in the way of rapid driving of tunnel headings. Letters have reached us from American contractors expressing incredulity as to the rate of progress in that tunnel which has been reported in these columns. To such incredulous ones it may be remarked that the freedom from dust in that tunnel is in all probability a large factor in the rapid progress which has been made. It must be remembered that the Brandt hydraulic drill is used in the Simplon tunnel, and there is therefore no dust whatever from the drilling operations. As for the dust produced by blasts, it is the practice in the Simplon to turn a jet of water from the high pressure pipes against the face immediately after a blast, which quickly lays the dust and enables mucking and drilling to be at once resumed.

Of course the Simplon tunnel has in addition an unusually perfect system of ventilation, which helps to dispose of the dust raised by a blast.

In this connection it is of interest to record the computations made by Mr. J. P. Carson, M. Am. Inst. M. E., in a paper read in September, 1890, before the American Institute of Mining Engineers. In that paper Mr. Carson discussed the size of power plant and fans necessary to secure good ventilation in driving rock tunnels, and his figures showed that the removal of rock dust was a large factor in the problem.

Reverting to the Simplon tunnel, it has been supposed that the rapid work done by the Brandt drills was one of the main factors in the rapid progress of the heading work. A study of the actual number of feet drilled per shift by these drills, however, shows that they are little, if at all, more efficient than the best of our American percussion drills.

Of course it will not be supposed for an instant that American mining and tunneling practice could be so altered as to discard the percussion drill and adopt the hydraulic merely to get rid of the dust. What can be done is to provide means for checking the dust from drill work and clearing it away after blasts. The authors of the paper under discussion have designed an excellent, and at the same time simple device for laying the dust after a blast. It might be termed a pneumatic-hydraulic cannon, or an air-water gun. It consists of a length of 6-in. pipe which is filled with water. This, after blasting, is ejected by compressed air in a fine mist, forming a spray that seizes upon the dust particles and clears the air for 40 ft. or more in front of the breast of the tunnel or stope. To the practical man, perhaps, this will be considered the most useful part of Messrs. Haldane and Thomas's paper. At any rate, the device appears worthy of wide imitation.

The use of a can of water from which a jet is forced by air pressure into the drill hole through a pipe, is by no means a novel device. Indeed, there are several special "cans" on the market for this purpose. The feature that is novel, in the device described by the authors, is the use of a spray nozzle at the end of the pipe. In American practice it is customary to use water not for the purpose of laying the drill dust but for the purpose of washing out the sludge, so as to leave clean rock for the bit to strike upon. Water, in this country, is used thus only in soft rocks that make sludge rapidly, and is then used in such abundance that no sludge can accumulate in the hole. The very abundance of the water required has probably prevented the spread of this system of "tending chuck"; but if a small spray will suffice for dust laying purposes, it ought certainly to be used wherever drilling is done underground.

Rock crushers, housed or unhoused, are usually very disagreeable to work around. Occasionally one sees a plant where a spray of water is used to lay the dust. Such a spray may be directed upon the rock as it enters the crusher, and it acts in a satisfactory manner except in one particular, namely, that where the rock dust "balls up" readily the screens are apt to be clogged. With many kinds of rock, however, no such trouble occurs, and it will then prove good economy to use a water spray, for the rock dust cuts out the bearings of all machinery in the plant in spite of devices used for excluding dust.

Among the industries in which rock dust is present in volume, probably none exceeds in importance the manufacture of Portland cement. If the investigations of these English engineers may be relied upon, there is at least a possibility that work in a cement mill may mean shortened life for those exposed to the dust. We know of no investigations that have ever been made in this field, but it is a matter which demands attention. The manufacture of Portland cement is still a new industry in this country, and a considerable number of years of exposure to dust is required before the tendency to pulmonary disease develops. It may readily be, therefore, that hundreds of workmen are laying to-day the foundations for a probable death from pulmonary disease at an early age, while both they and their employers are unaware of the fact.

Of course it may be possible, on the other hand, that the dust from cement clinker is like the dust from coal or that from iron ore in its effect on the pulmonary system, and produces no tendency toward tubercular disease. But at least the facts ought to be ascertained and it would appear to be a very suitable subject for investigation by the National Government, through the Bureau of Labor. Such investigation might well include the whole subject of the effect of stone dust of all sorts on those exposed to it.

LETTERS TO THE EDITOR.

Stresses in Riveted Joints.

Sir: Regarding the question raised in the letter, entitled "The Stresses in Riveted Joints," published in your last issue, I have to say that European engineers usually add 20% to the number of rivets found by computing a riveted joint, on account of the unequal distribution of the stresses between the rivets. Very truly yours, "L. H.," C.E.

New York City, June 10, 1904.

Grounding Bridge Trusses Carrying Electric Railways.

Sir: Commenting on an item in your issue of June 2, page 532, relating to an "accident from short circuited electric current," the obvious remedy for all such accidents is to properly ground the frames of all bridges over which electric cars pass, either by electrically bonding to the water pipe or to a copper plate sunk in the river. I am surprised that it was not done in the present case.

The immediate cause of the accident does not seem quite clear. First, the water pipe and truss bar must have been momentarily at least in contact, for it would be impossible for a 500-volt current to "jump the intervening space" however small; but it is not explained how the arc could have continued for two or three minutes, as reported, because this, of course, implies a good connection of the frame with the trolley wire for that length of time. The report indicates also that the arc continued until noticed by a passer-by. Now it is not likely that a trolley car would be left on the bridge that length of time with its pole touching the trolley wire and resting on one of the overhead parts of the bridge, which is the inferable way in which the trolley wire became grounded on the bridge, although the report does not state clearly. I would call attention, however, to the last line of the report, stating that "the planking of the bridge has caught fire several times from imperfect connection of wires;" this indicates a dangerous condition, in which the trolley wire was permanently grounded on the bridge, leading un-

doubtedly to serious current leakage, quite aside from danger to the structure. It shows the importance of a perfect ground connection of the trusses of all bridges carrying trolley circuits as well as of the rails passing thereover, in which case any accidental or temporary ground of the trolley wire would be immediately discovered by the action of the circuit breakers at the power station, and danger be avoided, besides compelling the immediate repair of the fault. George W. Colles.

408 Uihlein Building, Milwaukee, June 8, 1904.

West Point as a School of Engineering Economics.

Sir: May the writer, as a graduate of West Point, express his sincere appreciation of your editorial in the Engineering News of June 2, 1904, relative to the question of modeling civil engineering schools after West Point.

You have seized upon the vital point in the course of instruction at the Military Academy in a way not often found among our civilian friends in these days. The keynote of the whole course is thorough grounding in the fundamentals without any attempt at specialization. In addition, there are the discipline, co-ordination of different departments, mental and moral training, so well described by you.

The writer has had occasion to familiarize himself with the practical side of several different branches of engineering since his graduation from the academy. He has always found that, with the course at the academy as a foundation, the technical working manuals of any branch of engineering could be read easily and understandingly. He thinks he could pay no greater tribute to his Alma Mater.

He has frequently observed that the engineering graduates from technical schools are apt to be specialized in some one direction; in every case where this has been apparent it has not been in the direction in which the student's energies were to be immediately applied. No school can make an engineer. West Point does not make a trained army officer, but it turns out a graduate so thoroughly grounded in the basis of all branches of the military profession, including engineering, that he is well prepared to take up with success any branch to which he may be assigned. Surely, the technical schools of the country will have subserved their most useful ends if they turn out graduates properly prepared to take up any branch of engineering, although they may not be trained engineers in any one branch.

There is but one thing the writer would like to add to your editorial, and that is this: Military engineers are trained in economy just as thoroughly as they are in other branches of their profession. Economy is the watchword even in military operations where the cost is measured in lives instead of dollars. It may more often happen in military engineering that true economy is coincident with high first cost than in other branches; but true economy is the end sought in all cases, and that is what every engineer should seek. This statement is made simply because some of your readers may infer from the wording of your editorial that no attention is paid to economy in the training of the students at West Point.

Economy is a broader subject than first cost, and in the broader subject the students at West Point have a thorough training at the hands of the professor and instructors of engineering, although not much will be found on the subject in the text-books which are used as a basis of the course.

The writer thinks that even the military art is properly a branch of engineering—and one of the oldest. The art of war, in the course at West Point, is defined as having for its object, among other things, the planning of campaigns and battles so that the "greatest benefit may result from victory, and the least injury from defeat," and "so that one may be stronger than the enemy at the time and place of actual conflict." If this is not "engineering," it is at least true economics.

The great benefit of the discipline at West Point is the fact that it insures a reasonable, thorough and sustained daily effort on the part of the student, with perfectly regular habits. Skylarking one night and overworking the next are not conducive to either health or true efficiency, and all technical schools should have enough, at least, of the West Point discipline to prevent their students from so regulating their lives.

Very truly yours, John Stephen Sewell,
Captain, Corps of Engineers.

Washington, D. C., June 7, 1904.

Patents on Suspension Coal Bunkers.

Sir: With your kind permission I cannot leave unnoticed Mr. Wright's reply to my letter concerning the patented suspension coal bunker in your issue of May 19. Mr. W. says: "It is strange to engineers that he (A. Samuel Berquist) can take the stand he does, etc."

Grant for the sake of argument that I am ignorant of coal and ore handling appliances, but what about the Link Belt Engineering Company? They at least must know something about coal handling machinery, and that company not only respects my patent rights, but also recognized the same by entering into a contract with me to build bunkers under my license.

The C. W. Hunt Co., whom I understand to be the pioneers in the field of coal handling machinery, have also recognized my rights in this matter, as well as all my customers, some of whom have scrutinized the patent very closely. Mr. W.'s own company also came very near acknowledging the patent and its merits, as they entered into negotiations for a license from me under which they could build bunkers.

In order that there may be no misunderstanding about what I claim and what I have actually a patent upon, which patent has not been declared invalid by any court of law, I append herewith the claims as granted by the United States Patent Office in the Letters Patent dated May 30, 1899, issued to me and bearing the number 625,947:

(1) A storage bin or bunker suspended at its edges and having its sides and bottom mainly disposed in a curve of such a character that the strains set up by the load to be carried will be resisted and absorbed by the tensile strength of the material of which the bin or bunker is composed, substantially as described.

(2) A storage bin or bunker suspended at its edges and having its sides and bottom disposed in a curve which is approximately that which would be assumed by the material were it similarly suspended in a flexible receptacle, substantially as described.

(3) A storage bin or bunker consisting of side beams, suitable supports on which said beams are carried, a body portion of sheet material hanging from the side beams and means for resisting the tendency of the supporting beams to be forced toward each other, substantially as described.

(4) A storage bin or bunker consisting of side beams, supports on which said beams are carried, a body portion of sheet material hanging from said side beams, and internal struts for resisting the tendency of the supporting beams to be forced toward each other, substantially as described.

(5) In a storage bin or bunker, the combination with suitable supports, of a pair of girders, each girder consisting of a web and suitably disposed angle bars and having a portion of the web extending beneath the angle bars, a body portion of sheet material connected to the extending portions of the web, and disposed in a curve of such a character that the strains set up by the load to be carried will be resisted by the tensile strength of the material of the body, substantially as described.

(6) A storage bin or bunker consisting of side beams, supports in which said beams are carried, a body portion of sheet material hanging from the side beams, means for resisting the tendency of the side beams to be forced toward each other, and suitably braced ends, substantially as described.

(7) A storage bin or bunker consisting of side beams, supports in which said beams are carried, a body portion of sheet material hanging from the side beams, means for resisting the tendency of the side beams to be forced toward each other, and ends consisting of flat plates suitably braced, substantially as described.

(8) In a storage bin or bunker, the combination with suitable columns or pillars, of side beams carried thereby, a body portion of sheet material hanging from the side beams, and means for resisting the tendency of the side beams to be forced toward each other by the load in the bin or bunker, substantially as described.

(9) A bin or bunker consisting of an unbraced curved body portion, suitable ends therefor, suitable supports for the body portion, and means for overcoming the tendency of said supports to approach each other under the strain of the load of the material in the bin or bunker, substantially as described.

Yours very truly, A. Samuel Berquist.

Brooklyn, N. Y., June 10, 1904.

Notes and Queries.

A. K., New Orleans, La., writes:

Will you please answer the following question through Engineering News: Given a cubic foot of rock weighing 165 lbs. which will absorb no water and a cubic foot of concrete weighing 125 lbs. which will absorb 20 lbs. of water; A claims the effective weights of such rock and concrete on a sunken mattress are respectively 102.5 and 82.5 lbs (water being assumed to weigh 62.5 lbs. per cu. ft.). B claims the effective weights are respectively 102.5 and 62.5 lbs. Which is correct?

A is correct because the total weight per cubic foot of the concrete after it is water-soaked will be 145 lbs. per cu. ft. If the reader has difficulty in understanding this, let him reflect that the pores in the concrete affect the stone's weight exactly as if they were concentrated in a single cavity. If the water is excluded this cavity will produce a buoyant effect as it would not do if it were filled with water. A glass bottle, for example, will float if empty, but will sink if filled with water.

SOME COMPETITIVE TESTS OF ROCK DRILLS FOR AIR CONSUMPTION.

In a paper by Messrs. J. B. Carper, E. Goffe and W. C. Docharty, recently read before the Mechanical Engineers' Association of the Witwatersrand, some very interesting data were given as to the air consumption of a number of English and American rock drills. The authors state that they endeavored to conduct a fair and unbiased trial of all the rock drills procurable, which included nearly all of those on the Johannesburg market. The object of the trials was to obtain the quantity of air consumed by the different makes and sizes of drills while doing the same work.

The method of making the tests [illegible] as follows: All the holes were drilled in a block [illegible] granite, 2 ft. thick, having the same densit[illegible] hardness as that of Peterhead granite. [illegible] block was bedded in concrete, and the drills [illegible] mounted on a quarry bar, supported by [illegible] nes firmly set in concrete. All holes were d[illegible] vertically, and an abundance of water was us[illegible] There were two air receivers, 5 × 20 ft. each, [illegible] ng a combined capacity of 757 cu. ft. The [illegible] compressor was worked until the gage on the r[illegible] ers showed a pressure of 80 lbs. per sq. in[illegible] the stop valve was shut, closing connectio[illegible] th the receiver. Drilling was then begun w[illegible] e machine to be tested, and continued witho[illegible] intermission until the gage registered 70 lbs. Th[illegible] achine was then stopped, and the depth and d[illegible] eter of the hole carefully measured. A similar [illegible] was made from 70 to 60 lbs.; and so on do[illegible] to 35 lbs. pressure. In working out the result[illegible] the capacity of the receivers was calculated f[illegible] every pressure (80 down to 35 lbs.), corrected [illegible] r temperature, and the air consumption r[illegible] ced to the equivalent of free air at 70° F. [illegible] 24.8 ins. barometer.

The first set of tests was upon 14 drills having 3¼-in. cylinders, and using 3-in. bits. Our space will not permit reprinting the tabulated results of all these tests, but we have calculated the average results of the tests on 13 of the drills, eliminating one drill which behaved in a very erratic manner, and likewise eliminating a few individual runs which showed great departure from other performances of the same make of drill. The following table gives the average results of 13 drills having 3¼-in. cylinders and using 3-in. bits:

Air pressure, lbs.	80-70	70-60	60-50	50-40	40-35
Lin. ins. drilled per min.	1.3	1.1	1.0	0.6	0.5
Cu. ft. free air per min.	124	117	100	70	60
Cu. ft. free air per lin. in. of hole	95.3	103.4	100.0	116.4	120.0
Cu. ft. free air per cu. in. of hole	13.3	14.8	13.8	15.0	16.6

In studying this table we see that the air consumption per inch drilled is somewhat erratic, but it was much more erratic in individual tests. The reason for this may be ascribed in part to the lack of uniformity in the granite, in part to the personal equation of the driller, and in part to the efficiency of the drill itself at different air pressures. Doubtless the tempering and sharpening of the bits had a marked effect also. Each drill, it should be stated, was run by men selected by the agent of the drill, so that the personal equation becomes a factor of importance. However, the personal equation of the driller is by no means of so great importance on short continuous runs like these as upon runs several hours long. In the trials each run was about 6 mins long; that it, a run of the drill during the drop of 10 lbs. in air pressure consumed on the average about 6 mins.

One thing, however, is strikingly and consistently shown in the above tabulation, namely, the rapid falling off of inches penetrated per minute with every drop in the air pressure. With air pressure averaging 75 lbs., we note that 1.3 ins. per min. was drilled, as against only 0.6 ins. per min. under an average pressure of 45 lbs. The lesson that this teaches is that it does not ordinarily pay to overload an air compressor with more drills than it is designed to carry, and that it never pays to use a main pipe so small as to reduce the air pressure materially.

It is interesting to note that American drills were well in the lead of competitors. The best record of all the 3¼-in. machines was made by a Rand "Slugger." Using a 3-in. bit, this drill showed the following results (see table below).

The excellence of the performance of this drill is well shown by comparing the results of its test with those above given as the average of 13 drills of the same size. Mr. Docharty attributes the poor showing made by most of the drills to poor valve design, resulting in cushioned blows, and he suggests that perhaps a study of these tests will lead some of the manufacturers to improve their valve designs.

There were only four 3-in. machines tested, and,

Air pressure, lbs	80-70	70-60	60-50	50-40	40-35	80-35
Length of run, mins.	7.166	7.583	8.550	11.666	8.416	41.381
Linear ins. per min.	1.48	1.10	0.98	0.54	0.44	0.88
Cu. ft. of free air per min.	91.1	84.0	76.4	52.8	46.1	69.2
Cu. ft. of free air per lin. in. of hole	61.5	76.9	78.0	96.7	106.3	78.3
Cu. ft. of free air per cu. in. of hole	8.70	10.80	11.04	13.68	14.90	11.08

while in some instances the results were erratic, the air consumption and speed of drilling (3-in bits) corresponded very closely with the data above given for the 13 larger drills. It should be noted, however, that no tests were made in deep holes, for under those conditions the larger machines would doubtless show their superiority. The fact that only shallow vertical holes were drilled should not be lost sight of in considering these tests.

One of the most valuable of the tests made was one with a 2¾-in. Rand "Slugger," using bits of different size. It has been claimed that the depth of hole drilled in a given time should vary inversely as the area of the hole, but there is little in the way of actual tests to substantiate this claim. While too much reliance should not be placed upon one or two tests, the following data tend to prove that in drilling granite the speed of drilling varies inversely as the square of the diameter of the bit. A 2¾-in "Slugger" with a 6¼-in. stroke gave the following results:

Air pressure, lbs.	80-71	71-67	60-52	50-44	80-44	
Diameter of bit, ins.	2 1/16	2	2 1/16	2 1/16	2–2 1/16	
Length of run, mins.	8.08	1 08	9.25	6.83	25.25	
Inches drilled per min.	2.19	3.81	1.81	0.95	1.78	
Cu. ft. free air per min.	72.5	224.2	50.2	47.3	64.0	
" " " " lin. in.	33.0	58.8	27.7	49.7	35.8	
" " " " cu. in.	9.88	18.72	7.83	14.03	10.45	
Air pressure, lbs.	80-70	70-60	60-50	50-40	40-37	80-37
Diameter of bit, ins.	3 1/16	3 1/16	3	3	3	3 to 3 1/16
Length of run, mins.	8.75	8.0	10.25	13.67	5.08	45.75
Inches drilled per min.	1.08	0.64	0.69	0.56	0 51	0.7
Cu. ft. of free air:						
Per min	69.7	72.0	56.8	43.8	33.2	55.4
Per lin. in.	64.2	112.4	81.7	77.3	64.3	78.9
Per cu. in.	8.75	15.26	11.56	10.93	9.11	11.09

It will be seen that with a bit of 2 1-16 ins. in diameter, the average speed was 1.78 lin. ins. of hole per minute; but with a bit of 3 1-32 ins. in diameter the average speed was only 0.70 lin. ins. per minute. A similar series of tests with a Climax machine of the same size gave an average of 1.1 lin. ins. of hole per minute with a 3-in. bit, as against 1.85 lin. ins. with a 2-in. bit. So far as we know, these are the only published tests of drilling done under precisely the same conditions with bits of different diameters, and it is much to be desired that further tests be made on different kinds of rock to establish the ratio of speeds, using different sized bits in the same drill. In a rock that makes sludge rapidly, as, for example, shales, slates and some porphyries, a drill using water under pressure for washing out the sludge will readily excel drills which depends upon the "chuck tending" of the drill helper. As illustrating this point, it may be mentioned that the Leyner-Water drill showed up very poorly in comparison with other drills in these tests for air economy; yet this same Leyner-Water drill has made some remarkable records in competition with other drills working in softer rocks which make sludge rapidly. Apparently the agents of the drills themselves did not in every case appreciate the difference in results that occur in drilling different kinds of rock, nor do the authors of this valuable paper mention this factor as being one of importance in comparing drill efficiencies.

REINFORCED CONCRETE PILES WITH ENLARGED FOOTINGS FOR UNDERPINNING A BUILDING.

By J. Albert Holmes.*

It became necessary recently to underpin the interior walls of a building in Boston, Mass., which had been erected on filled land. The exterior walls of this building had been originally supported on piles and had not settled, but the interior walls were unsupported, and it became necessary to underpin them. For this underpinning, concrete-steel piles with enlarged footings were designed and their construction was so novel and interesting that it seems worthy of a brief description.

The filling and soft material is about 20 ft. in depth, underlaid by stiff clay. The piles were placed in clusters under wall intersections and at column points, the load being carried to the piles by means of short I-beams.

The upper portion of the completed pile is 0.44 sq. ft. in section, and has four twisted steel rods of square section imbedded in the concrete.

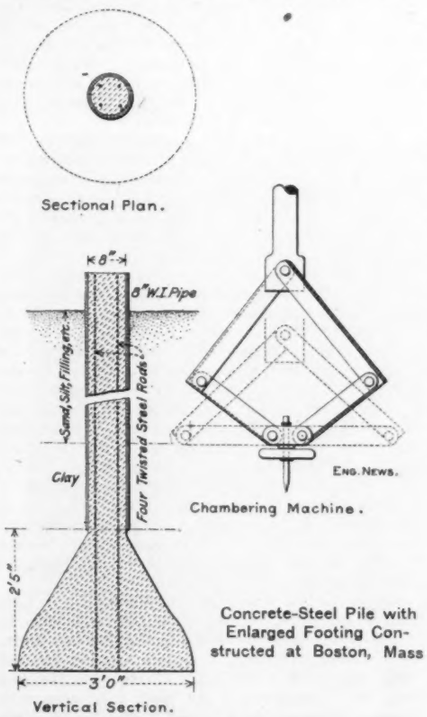
The pile is about 26 ft. in total length. The unique feature of the pile is its enlarged footing and the method of forming the chamber at its lower end.

*Engineering Staff, Charles River Basin Commission, Boston, Mass.

Reference to the drawings will indicate the different phases in the construction of the pile. The first operation is the driving of the 8-in. casing. This was rendered difficult by reason of the slight head room in the basement of the building. The casing was put down in 5-ft. lengths, passing through the filling and soft material and a foot or two into the clay, after which it was bored and washed out to a depth of 2 ft. 6 ins. below the end of the casing.

The chambering machine was then inserted and the chamber formed and washed out; the casing and chamber were then pumped dry, the steel rods placed and the concrete put in and tamped. When the concrete reached the top of the enlarged portion, the casing was withdrawn a foot at a time and the concrete allowed to fill the whole space formed by the pipe and its connections.

The chambering machine is constructed of angles, jointed as shown, and when closed up is



Concrete-Steel Pile with Enlarged Footing Constructed at Boston, Mass

placed in the casing and lowered to the bottom of the boring. The pin enters the clay and prevents side motion, and the disk prevents the machine sinking further into the clay. Saw teeth are formed on one leg of the angles; this makes the cutting edge. The machine is revolved from above, its weight giving sufficient pressure for cutting. The final position of the cutting arms is shown by the dotted lines.

An experimental chamber has been bored and afterwards cut through to determine whether or not the desired form and area had been obtained; the experiment was a complete success. The area of the footing is increased over that of the pile above sixteen times, or from 0.44 sq. ft. to 7 sq. ft.

This should be an excellent method for underpinning buildings or other structures where the working room is contracted, and a limited number of supports can be placed, carrying heavy loads, close to or below which excavations are to be made. Patent rights have been applied for. The writer is indebted to Messrs. Gow & Palmer, Civil Engineers and Contractors, 50 Congress St., Boston, Mass., for the drawings reproduced herewith.

THE INTERCEPTING SEWER SYSTEM on the south side, Chicago, has been completed, but the pumping station at 39th St. will not be ready for operation before next April. The sewer extends north from 73d St. to the pumping station, from which a tunnel conduit runs under 39th St. to the river. Its purpose is to check pollution of the lake by cutting off the various sewers which now discharge at the shore line. The work was done by day labor. The intercepting system on the north side is still uncompleted.

ANNUAL CONVENTION OF THE AMERICAN WATER-WORKS ASSOCIATION AT ST. LOUIS.

The city of St. Louis has been chosen as this year's convention city by a great number of societies and associations, technical, commercial and political. The national convention of the Democratic party, in July, and the international electrical and engineering congresses to be held in September and October, are prominent examples of a long list of gatherings which St. Louis will welcome in the next five months. The force attracting them is, of course, the Louisiana Purchase Exposition. In the selection of a convention place the argument for St. Louis was: "Everybody will go there, and we will be sure to have a big attendance; besides, most of us will go to the Fair anyway, and we might as well hold our convention there and save money."

The fact is, however, that St. Louis this year is not a good place to go to for saving money. Further, a convention cannot well serve two masters, and in the rivalry between convention business and World's Fair, the latter is apt to come out ahead. The American Society of Mechanical Engineers apparently took this latter view, and selected Chicago as the place for holding its joint meeting* with the British sister society, the Institution of Mechanical Engineers, many of the members visiting St. Louis after the meeting at Chicago was over. A similar course was adopted by the American Foundrymen's Association, which met last week at Indianapolis (as reported quite fully on another page of this issue), and thence went to St. Louis collectively, for a visit to the Fair. But, with occasional exceptions like these two, the present summer's conventions are in St. Louis itself.

One of the first technical conventions to come to St. Louis was the American Water-Works Association, which held its 24th annual meeting there last week. The meeting was very largely attended, there being present about 250 members (out of a total membership list of 400) and an equal number of ladies and guests. The convention extended over six days, Monday June 6 to Saturday, June 11, inclusive, and the program was so arranged that about half this time was available for the Fair. Morning sessions were held for transacting the business and technical work of the meeting, while the afternoons and evenings were used for excursions and for seeing the Exposition and its Pike. A steamer-ride down the Mississippi River, a trip to the Chain-of-Rocks pumping and filter plant of the St. Louis waterworks, and to the Anheuser-Busch brewery and a baseball game were among the excursion features of the meeting.

Professional Proceedings.

The technical work of the meeting included, as in previous conventions, much discussion of the three main troubles of the water-works man: the meter question, the related question of water rates, and private fire-services. In addition there were several excellent papers on subjects outside of this routine, though they were less eagerly discussed. A very brief review of the proceedings is given in the following:

Mr. W. R. Hill, late Chief Engineer of the Aqueduct Commission of New York City, read a paper on "Modification of the Plans of the New Croton Dam," wherein he explained in concise form the conditions which led him, after assuming office, to alter the plans for the new Croton Dam, and order a reconstruction of some of the completed work. The paper is reprinted elsewhere in this issue. As may be read there, it was found in removing some of the work already built that the condition of the rock on which it was founded was very poor, and in consequence the new foundation had to be carried materially deeper in order to make the structure secure.

This feature was emphasized in the discussion as pointing out the importance of thorough and expert preliminary investigation before planning any large engineering structure. Several instances were cited of the low esteem in which preliminary work is often held by laymen directing large enterprises, private as well as municipal. Prof. E. W. Bemis (Cleveland, O.) instanced the

*See the report of this meeting in our last issue, June 9, 1904.

failure of the foundations of a railway freight house in Cleveland as a blunder which, had it occurred in municipal practice, might have overthrown an administration. He believes that private corporations experience errors of this kind quite as frequently as municipalities, but with the latter very much more public criticism follows.

A subject discussed in the preceding annual meeting, that of algal growths in drinking water, was brought up again in a paper entitled "Experience with Growths in Water Mains," by Mr. O. T. Smith (Freeport, Ill.). The author reported that in 1895 the water supply of Freeport, Ill., acquired a bad taste and odor, which was finally traced to the growth known as crenothrix. The means adopted to get rid of the trouble were coagulation and filtration to remove the iron and the CO_2 in the water. A plant was designed and erected by the New York Continental Jewell Filtration Co.; lime-water is used as coagulant. The result is that all CO_2 is removed from the water (originally 21.4 parts per million), while the iron is reduced from 0.65-19.2 parts to 0.04 parts per million. This has prevented all new growth, and the old growth in the mains has been largely removed by frequent flushing. The author stated that a number of house services and meters had been completely stopped up with the growth, before filtration was begun. The iron found in the water was lowest at the pumping station, and greatest in the mains and in dead ends, due, doubtless, to the solvent action of the large amounts of CO_2 present.

Mr. S. A. Charles (Lexington, Ky.) stated that at Lexington, where growths of algae tend to increase as the temperature of the water approaches 70° F., the means used to prevent trouble are aeration, filtration, and a thorough system of flushing. Aluminium sulphate is used as a coagulant.

Mr. J. W. Alvord (Chicago, Ill.) presented a diagram of prices of cast-iron pipe for twenty years past, from quotations published in Engineering News. The three curves drawn (reprinted in our last issue, June 9, 1904) show irregular wave-like variations, with a period of about three years between maxima. No general rise or fall is shown.

An interesting paper, illustrated with numerous lantern-slide views, was presented by Mr. D. H. Maury (Peoria, Ill.) under the title "Some Recent Developments in Wells and Pumps." The new forms of well which are described in the paper were evolved by the author in the attempt to avoid the difficulties produced by the clogging of ordinary well-strainers. His method is to sink a well carrying a strainer of assorted gravel held between two concentric well-cylinders. This type of well is adapted to pneumatic sinking or any other method. It has been used with success at Peoria. On the subject of pumps, the author referred to the great advance in centrifugal pumps, or rather the development of turbine pumps in America within the last year or two. He reviewed the principal steps in this advance as reflected in the patent records, and expressed much confidence in the future value of this style of pump in waterworks service.

WATER METERS AND METER RATES.

It doubtless seems to many a self-evident proposition that water, like gas or electric current, should be sold by meter, and that therefore meters form a legitimate and essential part of any water-supply system. This view is quite generally held in water-works circles, and, if water departments or companies had only themselves to reckon with, nearly every service pipe in the country would soon be fitted with a meter. But the water-using public contains a strong element which holds otherwise, believing either that water should be free as air, or that a fixed nominal service charge should entitle them to all the water they want, whether for drinking or for washing out boilers or sprinkling lawns and sidewalks. This fact leads each year to numerous papers and discussions before the American Water-Works Association on the allied subjects of, first, the advantages derived from meters, and, second, how metered water should be charged for.

On the first question, Mr. Park Woodward (Atlanta, Ga.) presented a paper entitled "Meters, their Use and Benefits," in which he related the results secured in Atlanta, Ga., from universal metering. That city had very few meters in 1884. Then the consumption became so great that new pumps and a new force main seemed necessary. To reduce the large waste which was known to exist, meters were placed on all services, and consumers charged by meter. The result was a great decrease in pumpage and in coal consumption.

If meters had not been introduced our daily pumpage now would be about 25,000,000 gallons per day instead of 8,000,000 as it is, and the outlay necessary to put the plant in condition to meet the demands would have been over a million dollars more than has been spent on it.

The charge at Atlanta is 60 cts. net for 6,000 gallons or less, per month, and 10 cts. net per additional 1,000 gallons. The revenue of the water department has grown steadily.

Prof. E. W. Bemis (Cleveland, O.) in a paper on "The Meter System in Cleveland," described the results obtained by a rapid and extensive introduction of meters in that city. At present nearly half the services in the city are metered (25,030 as compared with 3,344 in 1901), and the per capita consumption has been decreased from 169 gallons per day in 1901 to 142 gallons per day in 1903. The author expects a reduction to 100 gallons by metering the remainder of the city. The paper is reprinted elsewhere in this issue.

The discussion showed a general appreciation by water-works men of the importance of metering. Mr. J. W. Alvord (Chicago), however, questioned whether it could be stated that meters are economical in all cases; admitting the valuable results produced by meters, and their necessity in many cases, he holds it has not yet been shown that metering is a paying proposition in all cities, or that in any one city it is economical to meter all services. On the question of cost of repairs to meters, Mr. S. A. Charles (Lexington, Ky.) reported that with all service-pipes metered for fifteen years past, he had spent less than 20 cts. per meter for repairs during this entire period, the repairs being mainly for renewal of gear-trains. Referring to the style of setting used at Cleveland, where the meter is set high up in the (vertical) sewer pipe and the pipes are turned up to reach the meter, he advocated in preference the use of extension dials, with the meter set in the straight line of pipe at the bottom of the setting. Several examples were cited of the special value of meters in reducing the consumption of water where the available water-supply is limited.

The subject of water rates under the meter system was treated by Mr. J. B. Heim (Madison, Wis.) in a paper on "Meter Rates," and by Mr. F. C. Kimball (Boston, Mass.) in a paper entitled "The Equity of a Minimum Charge for Metered Services." The paper of Mr. Heim is an argument against charging for metered water by uniform rate, and in favor of a sliding-scale rate with a fixed minimum yearly charge. The paper includes a table giving the results of an inquiry in 88 different cities as to method of charging and annual income per consumer. By far the larger number favor a sliding-scale, while a minority favor a flat rate per unit amount supplied. In Madison the question was finally decided by adopting a sliding-scale charge; moreover, a minimum charge per consumer of $2 for six months was fixed. A decision of the State Supreme Court two years ago in a test case against the minimum rate (in Manitowoc, Wis.) sustained the legality of a minimum charge. The subject of minimum charge was further developed by Mr. Kimball, whose argument was based on the fact that only a small part of the expense of operating a water department varies with the pumpage, while all fixed charges and much of the operating expense are unaffected by a small decrease in pumpage. A fixed charge per year for the service offered, aside from any question of amount of water used, is therefore reasonable.

In discussion, Mr. G. H. Benzenberg (Milwaukee, Wis.) corrected some figures cited by Mr. Heim in comparing the water departments of Madison and Milwaukee. Incidentally he expressed his belief in the minimum charge plan as being fair to user as well as to water department. It appeared from his remarks that while Milwaukee has about 5¼ million dollars invested in water-works plant, all but half a million of this has been paid off from the earnings of the system, so that at present, interest is figured only on the small amount of outstanding bonds. While Milwaukee has thousands of families paying less than $1 per year for water (exclusive of the annual charge of $1 for meter-reading), the water department pays for all new construction as well as maintenance, and yields a profit of 5%. Mr. Kimball attacked the practice of figuring interest on only the outstanding bonds, because it would vitiate any comparison of results with other cities. But Mr. Benzenberg held that the effect is not undesirable, on the ground that any attempt to figure water rates by comparison with other cities is wrong and impossible.

This last matter was further developed in the report of the Committee on Standards for Water Rates, submitted by Mr. Benzenberg. This report lays down the rule that since the water department of a municipality supplies a specific commodity (unlike other municipal departments), it should be operated strictly on a business basis, and independent of funds from the general treasury of the city. This should be the basis of managing municipal as well as private plants. As the elements of cost vary radically in different water systems, it is futile to attempt to establish a standard basis for charging; the most that can be done is to set down the various items entering into cost of water, which is done in the report in some detail. The report was adopted by the Association.

PRIVATE FIRE SERVICES.

A paper by Mr. L. N. Case (Duluth, Minn.) entitled "Private Fire Systems," described how the matter of preventing water-stealing or waste from private fire services has been dealt with in Duluth. Wherever the fire service is connected in the same pipe system as the ordinary service to the premises, the entire service is metered, and all water used for other than fire purposes is paid for at regular rates. In addition an assessed charge running from $5 to $50 per year is made for the fire service and inspection. A similar charge is made for private fire service fed independently of the regular supply to the premises. Such systems are frequently inspected and when evidences are found that water is used for other than fire purposes, an extra charge is made. The author does not favor placing meters on fire services, partly because they may obstruct full flow, and partly because they fail to register small streams.

Mr. A. M. Quick (Baltimore, Md.) presented a paper on "Water Service at the Baltimore Fire," which, besides giving a general description of the Baltimore water system and its use during the great fire,* discussed several special questions of fire service: (1) The adequacy of any water service to successfully cope with an emergency like the Baltimore conflagration; (2) the effectiveness of private fire service fixtures in protecting property; and (3) the possibility of the waste from broken water pipes in buildings destroyed by fire temporarily crippling the water service. The author's conclusions are:

(1) There are some fires which no water supply system, no matter how adequate it may be, will put out.
(2) Private fire services can do very effective work in protecting property, and their installation should therefore be encouraged within reasonable limits.
(3) Every water supply system should have a liberal excess of storage, pumping, or delivering capacity over the demands for ordinary domestic consumption to prevent the large increase in draft for fire service and waste from crippling the service in such emergencies.

The author shows that the supply and distribution system in Baltimore was adequate, and that the pressure did not fall below normal within the burning district while the fire engines were pumping their maximum amount, in spite of the waste from broken pipes. This was due to raising the pressure at the pumps and turning the high service supply (the Baltimore water system has four pressure zones) into the mains in that district. He also gives an estimate of the water used during the fire for fire service—70,000,000 gallons in two days—and an estimate of the waste through broken pipes during the week following—120,000,000 gallons. Several cases of saving property by private fire services are described in the paper in detail.

Some discussion on the subject of private fire services followed the report of the Committee on Insurance. The committee reported that it had conferred with the National Fire Protection Association in the attempt to agree upon a method

*See Eng. News, Feb. 11, 18 et seq., 1904.

of installing private fire lines which should be satisfactory to the water department as well as to the Underwriters. No definite results have been reached, and the committee will be continued through another year. Mr. D. R. Gwinn (Terre Haute, Ind.) described a 6-in. fire service put into a distillery at Terre Haute last year. Two 4-in. Crown meters are placed on the line in parallel, and between them across the line is a 6-in. bypass with a 6-in. valve, the latter being sealed. Ordinarily the two meters will deliver sufficient water for fire purposes, but should it be desired for any reason to get a greater flow, the sealed valve can be opened. The charge is $25 per month, which also allows a certain amount of water, the excess being charged at meter rates. The argument of the insurance men was presented by Messrs. Robinson and Blauvelt, who emphatically demanded either an automatic valve or no valve at all in fire services, so that no reliance on hand operation is required. No obstacles like meters are permissible on such lines. Mr. S. A. Charles (Lexington, Ky.) stated that his method is to supply through a meter, or to give a 2-in. pipe with suitable charge for its full capacity. When a greater supply is required than the capacity of a 2-in. pipe, he advises his customers putting in a roof-tank or other elevated storage. The report was also discussed by Messrs. H. O. Nourse (Chicago, Ill.), and D. H. Maury (Peoria, Ill.). Mr. Maury objected to a hand-operated valve in a fire-service on the ground that in case of fire there is no time to operate such a valve. He also objected to multiple-nozzle hydrants, citing cases where but three streams were secured out of twelve nozzles, the valve-stems of the others having broken off. He prefers a greater number of hydrants, either single or double-nozzle. In this connection it may be noted that on request to the association a committee was appointed to recommend standards for hose-couplings to fire-hydrants.

Several papers were read by title only and received no discussion. Mr. J. C. Trautwine, Jr., (Philadelphia, Pa.), contributed a paper on "Resistance due to Bends in Pipes; Application of Existing Formulas to a Given Case," and Miss O. Simin (Philadelphia, Pa.), a paper entitled "Resume of Investigations Respecting Water Hammer." The latter paper is a full summary of past work on the subject of water hammer, especially the work of Prof. N. Joukovsky of the University of Moscow. The formulas deduced by Prof. Joukovsky for the velocity of pressure wave and the increase of pressure due to sudden stoppage of flow are given, and diagrams illustrating the results of experiments made by him and Mr. N. P. Simin (Moscow, Russia), in 1897 and 1898 to verify the theoretical results. The formula for size of air-chamber obtained in this work is also given, together with Prof. Joukovsky's conclusion that relief valves are preferable to air-chambers in the general case.

The report of the Committee on Uniform Classification of Accounts, by Mr. D. R. Gwinn (Terre Haute, Ind.), indicates that no absolute uniformity in conducting water-works accounts is attainable. The committee undertook to compare the office methods and forms prevailing in water-works throughout the country, and on investigation found them so diversified that it was hopeless to try to evolve a standard system. Acting-president M. R. Sherrerd (Newark, N. J.), suggested that it might be more practicable to attempt formulating a standard form of annual report, and on motion the committee was continued with this object, its title being changed to Committee on Uniform Annual Report.

The business proceedings of the meeting included the provisional adoption of some amendments to the constitution of the association, the election of officers and the selection of a place for next year's convention. West Baden, Ind., was selected after an interesting discussion. The newly-elected officers are:

President, M. R. Sherrerd, Newark, N. J.; Vice-Presidents, B. C. Adkins, St. Louis, Mo.; F. H. Bennett, Oswego, N. Y.; C. E. Rowe, Dayton, O.; D. H. Maury, Peoria, Ill.; A. A. Tucker, Memphis, Tenn.; Secretary-Treasurer, J. M. Diven, Elmira, N. Y. Finance Committee, H. E. Keeler, Chicago, Ill.; A. Milne, St. Catherines, Ont.; R. J. Thomas, Lowell, Mass.

The association's membership was increased by the election of some sixty new members at the St. Louis meeting, making a total of nearly 500. The management shows a cash balance of about $150. The association has been invited by the joint committee of the Union Engineering Building in New York City to take a share in the accommodations of the building, but declined the invitation on the grounds that it has no permanent funds and no large library, and only rarely holds its meetings in New York City.

TEST OF A 30-IN. PREMIER METER, AT THE TESTING PLANT OF THE NATIONAL METER CO.

By Arthur S. Tuttle,* M. Am. Soc. C. E.

On May 18, 1904, a number of water-works engineers practicing in the vicinity of New York, witnessed a test of the 30-in. Premier meter, described in the issue of Engineering News of May 19. The meter was tested at the works of the National Meter Co., in South Brooklyn.

For the purpose of testing large meters, this company has constructed a weir which is fully equipped with facilities for accurately measuring the flow of water. This weir was described in the report of the writer to the Board of Street and Water Commissioners of Jersey City, N. J., in 1899, on the accuracy of 20-in. and 36-in. Gem Meters for use on the Belleville mains, and also in a paper published in the Proceedings of the American Society Civil Engineers for May, 1904, by Arthur H. Diamant, Jun. Am. Soc. C. E. on "The Installation of a Pneumatic Pumping Plant."

FIG. 1. VIEW OF METER-TESTING PLANT OF THE NATIONAL METER CO., SOUTH BROOKLYN, N. Y.

From the former report the following description has been prepared, revision having been made to conform with later alterations.

The testing weir is a brick structure, about 24 × 40 ft. in area and about 10 ft. deep; the weir chamber is L-shaped and occupies the whole of one end, where it has a width of 8 ft., and all but about 6 ft. of one side, where it has a width of 12 ft.; the remainder is used in part as a catch basin for the water passed over the weir, in part as a pump chamber, and in part as a meter vault. In operation, enough water from the city main is first admitted to the chamber for conducting the test; the supply is then shut off and the pump is started, drawing its supply from the catch basin and forcing it through the meter and into the weir tank, whence it escapes over the weir notch and returns to the catch basin to be again used. The pump is of the horizontal centrifugal type with vertical spindle, geared to and operated by a 30-HP. Nash gas engine. After leaving the pump and before entering the meter the water is passed through a small chamber containing a wooden screen and baffles, which serve to break up the eddies formed by the pump, and to remove the air. The meter is placed at such an elevation that the whole of its body is below the water line in the weir chamber.

The weir crest is formed by a cast iron plate 25 ins. wide and 1⅜ ins. thick, extending the whole width of the weir chamber, with its inner face flush with the face of the brick wall on which it rests. For the tests of the 30-in. Premier meter the notch was 5.7422 ft. long. The sides forming the notch of the weir were made of cast iron plates of the same thickness as the crest plates and 30 ins. wide; they were extended beyond the side walls of the chamber so as to give a tight joint, and were so placed that the edges of the notch at the opposite ends of the weir were equidistant from the walls of the chamber. The lip of the weir was formed by beveling the downstream face at an angle of 45°, leaving the edge ¼-in. in thickness and truly planed. The notch was rectangular, the edges true, and the crest level.

The apparatus for measuring the head on the weir consists of two 12-in. cast iron pipes set on end, located in front of the catch basin and cross connected by a 2-in. pipe from which a branch of the same size leads through the side walls of the catch basin, and then down and along the floor of the same into the weir chamber, then along the floor of the weir chamber to a transverse pipe, branching at right angles in both directions at a distance of 6.3 ft. from the face of the weir. These transverse arms are parallel with the face of the weir and extend completely across the chamber. They are raised about 6 ins. above the floor and are perforated on the top with 18 holes 3-16 in. in diameter and about 6 ins. apart. The distance from the measuring boxes to the nearest perforations was about 24 ft., with six right-angle bends.

In one of the measuring boxes an automatic gage, made by the meter company, was set up for obtaining a continuous record of the head on the weir. It consisted of a zinc float 10-ins. in diameter by 6 ins. deep, carrying a vertical 1¼-in. brass rod, to which a pencil was attached with its point pressing against a sheet of paper wrapped around a wooden drum 12 ins. in diameter. The drum was connected to a clock movement, giving it one revolution in two hours. A second pencil was rigidly attached to the fixed frame carrying the drum, and was set at the relative elevation of the weir crest, so that the actual head was recorded. In the other box a hook gage was set up; this instrument was made by W. & L. E. Gurley, and was graduated to hundredths of a foot on a metal face for a length of 2.3 ft., with a micrometer attachment and vernier by which thousandths of a foot could be distinctly read.

For determining the correction to be applied to

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the hook gage reading to obtain the actual head, and for setting the datum pencil of the automatic gage, the measuring boxes were disconnected from the weir chamber prior to the test and connected into the bottom of a water pail, which was hung under a fixed hook, carefully set to the exact height of the weir crest. Water was then added to the pail until it reached the level of the point of the fixed hook, standing at the same elevation in the pipes used for the hook gage and float gage measurements, making it possible to determine accurately the datum for each and avoiding error due either to wave motion or leveling instrument, much more reliable than the occasional readings of the hook gage, the latter were omitted from the records and reliance was placed entirely upon the automatic register.

The 30-in. Premier meter register reads to 1,000 gallons, but by an independent dial on the upper right hand corner of the register face, the reading can be made to 100 gallons and further subdivided by eye to 20 gallons. During the tests the meter readings were taken at intervals of five minutes, but the rapid motion of the pointer made it impossible to read closer than 50 gallons, and even then was the cause of some uncertainty.

chase Exposition, 13 additional ... under similar conditions to those ... scribed, and the results are shown ...

Diagram Fig 4 shows the volume ... the 30-in. Premier meter during ... by a 12-in. meter in previous tests ... volume determined partly by weir ... tank measurement.

The tests of the 12-in. meter ... meter registration for main ... about 2.75 to 6.5 ft. per second, ... responds with the volume shown ... and tank measurements, and that ...

were made ... viously de... Table II. ...gistered by ... tests, and ...erms of the ... partly by ...

...s that the ...es of from ...tically cor... the weir ... velocities as ...

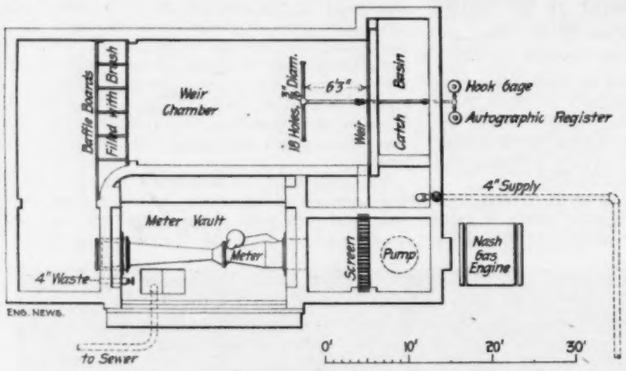


FIG. 2. SKETCH PLAN OF METER-TESTING PLANT, SHOWING RELATION OF PARTS.

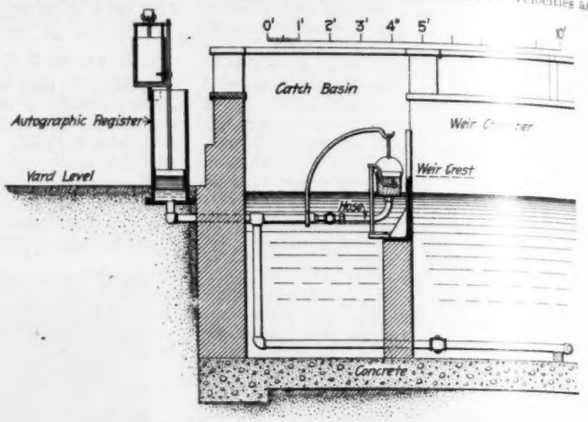


FIG. 3. ENLARGED SECTION OF WEIR CHAMBER AND CATCH BASIN, SHOWING DEVICE FOR ADJUSTING REGISTERING DEVICES TO WEIR LEVEL.

The wave motion in the weir chamber, due to irregularity in the action of the pump, was minimized by placing baffle boards at distances of 23 ft. and 26 ft. upstream from the weir, these extending the entire depth of the chamber. The boards composing each set of baffles were separated about 1 in. at the joints, and the space between the sets was filled with closely packed brush.

The entire equipment is shown by the accompanying view and drawings, Figs. 1, 2 and 3. The drawings, Figs. 2 and 3, give a plan and sectional view of the plant and show the method of determining the level of the crest of the weir for the automatic record. The drawings also show the position of the meter tested.

Four tests were made on May 18, each of 40 minutes duration. The head on the weir was

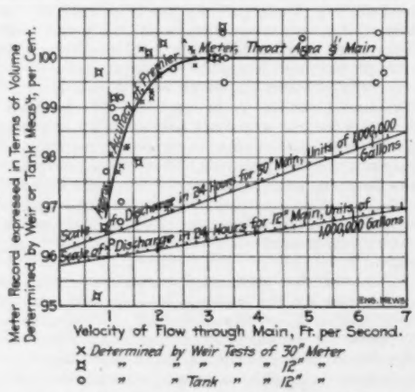

Meter Record expressed in Terms of Volume Determined by Weir or Tank Meas'ts, per Cent.
100
99
98
97
96
95
1 2 3 4 5 6 7
Velocity of Flow through Main, Ft. per Second.
Meters, Throat Agns 6" Main
Premier
Venturi
Scale of Discharge in 24 Hours for 30" Main, Units of 1000,000 Gallons
Scale of Discharge in 24 Hours for 12" Main, Units of 100,000 Gallons
ENG. NEWS
× Determined by Weir Tests of 30" Meter
H " " " " " 12" "
○ " " Tank " " 12" "

Fig. 4. Diagram Showing Volume Registered by 30-in. and 12-in. Premier Meters in Terms of Volume Determined by Tank and Weir Measurements.

maintained as nearly uniform as possible during each test, and the velocity of flow through the main averaged about 2.7 ft., 2 ft., 1.7 ft. and 1.2 ft. per second, respectively. Owing to lack of power it was not possible to obtain a higher velocity of flow, the new engine planned for use in testing large meters and for higher velocities, not yet having been installed. The engineers of the meter company, having found that the continuous automatic record of head on the weir is

The tests were in charge of Mr. Lewis H. Nash, M. Am. Soc. M. E., Chief Engineer of the National Meter Co.; Mr. John H. Norris, M. Am. Soc. M. E., Assistant Engineer of the National Meter Co., and Mr. Arthur S. Tuttle, M. Am. Soc. C. E., the inventor of the meter. The results obtained are shown by Table I.

Before shipping this meter to St. Louis, for which place it is destined as a part of the National Meter Co.'s exhibit at the Louisiana Pur-

TABLE I.—Showing Results of Tests of a 30-in. Premier Meter Made at the Testing Weir of the National Meter Co., Brooklyn, N. Y., May 18, 1904.

Duration. Min.	Head on weir—feet. Max.	Min.	Avge.	Gals. measured. Weir Record.	Meter Record.	Meter record, expressed in terms of volume determined by weir measurement. %	Velocity in main. Ft. per Sec.
				Test No. 1.			
5	.794	.782	.7861	29,082	29,000	99.7	2.640
5	.786	.781	.7826	28,888	29,050	100.6	2.622
5	.803	.780	.7910	29,354	29,550	100.7	2.665
5	.801	.783	.7945	29,549	29,450	99.7	2.682
5	.808	.787	.7960	29,633	29,550	99.7	2.690
5	.803	.791	.7956	29,611	29,800	100.6	2.688
5	.803	.788	.7943	29,538	29,700	100.5	2.681
5	.802	.785	.7932	29,475	29,500	100.1	2.676
40	.808	.780	.7917	235,130	235,600	100.20	2.668
				Test No. 2.			
5	.671	.653	.6560	22,269	22,250	99.9	2.021
5	.662	.653	.6565	22,294	22,200	99.6	2.024
5	.657	.649	.6555	22,243	22,050	99.1	2.019
5	.664	.649	.6536	22,146	22,100	99.8	2.010
5	.660	.650	.6545	22,192	22,000	99.1	2.015
5	.668	.651	.6541	22,172	22,200	100.1	2.013
5	.661	.647	.6521	22,070	22,100	100.1	2.003
5	.669	.646	.6551	22,223	22,100	99.5	2.017
40	.671	.646	.6547	177,609	177,000	99.66	2.015
				Test No. 3.			
5	.585	.574	.5801	18,567	18,500	99.6	1.685
5	.587	.574	.5801	18,567	18,300	98.6	1.685
5	.589	.571	.5790	18,514	18,400	99.4	1.681
5	.583	.570	.5785	18,490	18,350	99.2	1.678
5	.583	.570	.5798	18,552	18,350	98.9	1.684
5	.593	.571	.5790	18,514	18,300	98.8	1.681
5	.586	.573	.5790	18,514	18,400	99.4	1.681
5	.589	.571	.5786	18,495	18,300	99.0	1.679
40	.593	.570	.5793	148,213	146,900	99.11	1.682
				Test No. 4.			
5	.466	.454	.4596	13,162	13,100	99.5	1.195
5	.469	.453	.4626	13,291	12,750	95.9	1.207
5	.474	.454	.4608	13,215	12,900	97.6	1.200
5	.478	.464	.4598	13,172	12,800	97.2	1.196
5	.472	.455	.4643	13,364	13,100	98.0	1.213
5	.465	.447	.4562	13,014	12,750	98.0	1.181
5	.468	.452	.4598	13,172	12,750	96.8	1.196
5	.464	.448	.4555	12,986	12,800	98.6	1.179
40	.478	.447	.4598	105,376	102,950	97.70	1.196

low as 1 ft. per second, the difference between the weir and meter record is less than 3%.

The points located in the curve of comparison for a 30-in. meter show a similar relation as far as the tests have been carried, while the theory under which the meter is designed gives ample ground for assuming that for the higher velocities it will give results as satisfactory as those obtained with the 12-in. meter.

For cases where an accurate measurement of flow is desired, when it is at a lesser rate than corresponds with a velocity of 1 ft. per second in the main, the National Meter Co. proposes to increase the ratio between the area of the throat of the venturi tube and that of the main, thereby making the meter reliable for a stream of any size.

While the weir tests of the 30-in. meter were being made on May 18, tank tests of a 12-in. meter were also conducted. The water was admitted to the meter from a tank in the tower of the shop, giving a pressure of about 40 lbs., and the supply was controlled by quick acting gates operated by hand. In each test the supply gate remained open until 100 cu. ft. were registered on the meter. The water discharged was collected in a calibrated tank where it was readily measured, and the volume in each case and under varying

TABLE II.—Summary of Results of Tests of a 30-in. Premier Meter. Based on Weir Measurement.

Test No.	Duration. Min.	Rate of flow.—(weir measurement.)— Velocity in main. Ft. per sec.	Discharge in 24 hours.	Meter record, expressed in terms of volume determined by weir measurement. %
12	30	0.970	3,077,000	96.18
5	60	1.038	3,293,000	98.07
4	40	1.196	3,793,500	97.70
17	30	1.244	3,947,000	97.82
13	30	1.347	4,273,000	98.19
9	60	1.385	4,394,000	98.22
6	60	1.674	5,311,000	100.18
3	40	1.682	5,335,500	99.11
16	30	1.858	5,895,000	99.34
14	30	1.859	5,898,000	99.19
10	60	1.871	5,936,000	99.30
2	40	2.015	6,394,000	99.66
7	60	2.527	8,017,000	100.35
1	40	2.668	8,464,500	100.20
15	30	2.704	8,578,000	100.12
8	50	2.726	8,648,500	100.00
11	60	2.733	8,670,000	99.85

The weir used for these tests was 5.7422 feet long and had full end contractions. The Hamilton Smith Formula was used for the calculations. The tests were made during May, 1904, and Nos. 1 to 4, inclusive, were made on the 18th of the month.

rates of flow showed a close conformity with the meter records. It was noted in making these tests that the meter register responded immediately to all changes made in the control gates, showing that the meter is also particularly well adapted for use on service mains.

THE CAUSES AND PREVENTION OF MINERS' PHTHISIS.*

By J. S. Haldane, M. D., F.R.S., and R. Arthur Thomas (Member).

It was clearly shown by the late Dr. Farr, in his evidence before a Royal Commission which reported in 1864, that English metalliferous miners (not including ironstone miners) died in undue numbers from diseases of the lungs. In spite of the fact that the recommendations of that Commission were in the main carried out, the undue mortality still remains, and seems, indeed, to be associated with metalliferous mining in many, if not all, parts of the world.

The following table [not reproduced] summarizes the chief available statistics bearing on the subject, including those prepared in connection with our enquiry by Dr. Tatham, of the General Register Office.

On glancing over these tables, several facts appear very clearly:

(1) Apart from lung diseases and a slight excess of fatal accidents (many of which are not underground) among young miners, metalliferous mining in England is a very healthy and safe occupation.

(2) After the age of about 25 there is an extraordinary contrast, as regards the death-rate from lung diseases, between colliers and ironstone miners on the one hand and metalliferous miners on the other: the death-rate among metalliferous miners being very greatly in excess.

(3) Since 1890-92 there has been a great increase in the death-rate from lung diseases between the ages of about 25 and 50 among miners (including returned gold miners) living in Cornwall, so that between the ages of 25 and 45 their death-rate from lung diseases is now from 8 to 10 times that of colliers or ironstone miners of the same age. It should be remarked that "tin-miners" include a number of men who have previously worked in gold mines in South Africa or elsewhere.

A more detailed analysis of the causes of death would show that the variety of lung disease which is chiefly responsible for the excess of deaths is returned on the death certificates as "phthisis," although among the older men the deaths from "bronchitis" are also in excess.

CAUSES OF MINERS' PHTHISIS.

The prevalence of lung disease among metalliferous miners has been, and is still, attributed partly or wholly to a considerable variety of causes, which must be discussed one by one.

1. Absence of sunlight.—Although medical men and others often lay great stress on absence of sunlight as a predisposing cause of unhealthiness in miners, yet the fact that colliers and ironstone miners are an exceptionally healthy class, particularly as regards their marked freedom from phthisis, seems to show conclusively that absence of sunlight during work has nothing to do with miners' phthisis.

2. Exposure to high temperatures and sudden variations of temperature.—Miners are commonly exposed to high temperature underground, and to comparatively sudden cold on coming out, often with damp clothes on. Much stress has been laid on this fact, particularly in relation to lung diseases. Nevertheless, this cannot be an important cause of lung disease, for colliers are similarly exposed. Moreover, in England, colliers never wash and change their clothes at the pit-head, while Cornish miners almost invariably do so, in a heated building ("dry") provided on the mine. The effects of high underground temperatures on men and horses are certainly of considerable interest and economic importance, and we know from personal observations that in warm and moist air underground the body temperature often rises several degrees; but we can find nothing in the circumstances connected with the mode of occurrence of miners' phthisis to suggest that high underground temperatures are in any way connected with its causation.

3. Climbing of ladders.—It was formerly believed that the excessive strain of climbing ladders was closely connected with the lung disease prevailing among Cornish miners. It is doubtless the case that commencing lung disease must be hastened in its progress by the strain of climbing; but as the climbing of long ladders to and from work has now been reduced to a minimum in Cornish mines, while the lung disease still remains, it is clear that ladder-climbing is not an important cause of lung disease.

4. Insanitary conditions above ground.—The low death-rate from disease of every kind, particularly phthisis, among Cornish miners under the age of 25, seems to indicate that such factors as bad or insufficient food, insanitary housing, or hereditary predisposition to phthisis, have little to do with the production of miners' phthisis. During 1900-2 the death-rate from epidemic diseases (excluding influenza) was only .16 per 1,000 among tin-miners.

*Abstract of a paper read before the Institution of Mining and Metallurgy, May 19, 1904.

5. Gaseous impurities in the air underground.—Great stress has often been laid on gaseous impurities in the air as a cause of the unhealthiness of metalliferous mining. Collieries and ironstone mines are ventilated by fans, and air in large quantities is carefully led through all parts of the workings. In metalliferous mines, on the other hand, large fans are almost never used; few attempts are made to guide the air by doors, curtains, etc.; and, we must add, surprisingly little attention is usually given to the subject of ventilation. The consequence is, that those who are familiar with the care bestowed on ventilation in collieries and ironstone mines have little hesitation in ascribing the lung disease of metalliferous miners to bad ventilation.

While we fully agree that ventilation has been much neglected in metalliferous mines, and that much loss of money, and consequent injury to health, has resulted in consequence, we cannot agree that gaseous impurities in the air are mainly, or, indeed, to any considerable extent, responsible for the lung diseases of metalliferous miners. The Royal Commission of 1864, following the late Dr. Angus Smith and others, laid great stress on the gaseous impurities. It was then supposed that an excess of carbon dioxide (CO_2), or deficiency of oxygen, of less than 1%, was in itself very detrimental to health. Subsequent investigations have shown that there are in reality no grounds for this belief.

Particular Impurities.—The particular impurities present in the air of metalliferous mines are of several kinds. There is first of all the stone-dust produced, particularly in dry mines, by blasting and rock-drilling, and by shoveling, and removing the mineral mined. Then there is smoke produced by explosives themselves, and by candles. Finally the possibility ought also to be taken into account of the presence of pathogenic bacteria given off from men present in the mine.

To take the question of pathogenic bacteria—particularly tubercle bacilli—first, the possibility suggests itself that miners' phthisis is largely due to direct infection from man to man underground. We have naturally carefully considered the question how far miners' phthisis is, like ordinary phthisis, due to an invasion of the lung tissue by tubercle bacilli. The recent Transvaal Commission, basing their conclusion on a valuable report by the Transvaal Medical Society, concluded that the tubercle bacillus is very seldom present in miners' phthisis. Observations on Cornish cases, including men who have worked in the Transvaal, lead to a different conclusion. The sputa from a considerable number of miners who were suffering from phthisis were carefully investigated for us by a well-known bacteriological authority—Dr. Ritchie, of Oxford. He found that 74% of the specimens examined contained undoubted tubercle bacilli. As the tubercle bacillus is not infrequently absent for a time in the sputum of clear cases of tubercular phthisis, it would seem that possibly all the Cornish cases are really tubercular. If this be so the question of infection underground is a most pertinent one. It cannot be denied that when two men are working together in a close end or rise there is a great possibility that if one has tubercular phthisis he will infect the other; and probably tubercular infection is sometimes communicated in this way. Such infection by itself will, however, not explain the facts relating to miners' phthisis. In the first place the disease often manifests itself a considerable time after a man has entirely left underground work; and, secondly, it does not usually manifest itself until after years of exposure to inhalation of air containing stone-dust. Infection will certainly not by itself explain these undoubted facts, although the part played by infection in producing the disease must by no means be left out of account.

The influence of smoke from candles and the smoke from explosives themselves is probably inappreciable. In ironstone mines, where the men are extraordinarily free from lung diseases, we found a great deal of gunpowder smoke in the air, and the air is often quite thick with smoke, as a very large quantity of powder is used. The inhalation of particles consisting of almost any relatively soft and non-gritty material seems to cause very little tendency to lung disease. Colliers must certainly inhale a great deal of coal dust, and ironstone miners of ironstone dust, but apparently very little harm results, although after death the lungs are found to be considerably charged with the dust inhaled.

To come finally to stone-dust, the evidence seems to us extremely strong that this, and, practically speaking, this alone, is the cause of the lung disease which is so common among Cornish and other metalliferous miners.

In the first place, it is well known that the inhalation of dust from the mechanical disintegration of hard stone and other hard material gradually produces phthisis and other lung diseases. Thus among potters, who are exposed to the inhalation of flint-dust, and among cutlers, etc., who are exposed to dust from grinding, the death-rates from lung diseases, as shown in the Decennial Supplements to the Registrar-General's reports, are very similar, at successive age-periods, to those of tin miners. There are also many other occupations where men are exposed to stone-dust of various kinds, and which are known to be unhealthy owing to a great tendency to lung disease, although definite official mortality statistics are not available.

If stone-dust inhalation is the true cause we should expect that the men most exposed to dust would suffer most from lung diseases. To test this and other points we asked the Sub-Registrars for the Redruth District of Cornwall to make enquiries as to the work which had been done by the miners who died during the years 1900-2. The results of this enquiry showed in the clearest way that the rock-drill men, who are certainly by far the most exposed to dust, are also by far the most liable to miners' phthisis. It was found, in the first place, that the death-rates at different ages for all miners in the Redruth District were practically the same as for all miners in the whole of Cornwall. Out of 320 deaths, 141 were of men who had previously worked rock-drills at one time or other. Of the 141 who had worked rock-drills 133, or 94%, died of lung disease, and the average age at death was 37.2 years. Of the 179 men who had not worked rock-drills 120, or 67%, died of lung diseases, while the average age at death was 53. The following table shows where the men had worked and the causes of death.

	Phthisis.	Other lung diseases.	All other causes.	Total.	Average age at death.
Transvaal only	47	2	1	50	36.3
Cornwall only	26	7	4	37	37.5
Cornwall and Transvaal	29	..	3	32	36.4
Cornwall and India	3	..	..	3	37
Cornwall and America	1	..	..	1	32
Cornwall and West Africa	1	..	..	1	35
Cornwall, India and Transvaal	3	..	..	3	35
Cornwall, Transvaal and America	2	..	..	2	37
America only	4	2	1	7	43.9
India only	2	..	..	2	41.5
America and Transvaal	2	..	..	2	41.5
Brazil and Transvaal	1	..	..	1	40

The following table shows the effect of the deaths of rock-drill men on the death-rate among miners in the Redruth district:

DEATHS PER 1,000 MINERS LIVING, REDRUTH DISTRICT, 1900-2.

	Ages 15-20.	20-25.	25-35.	35-45.	45-55.	55-65.
Including men who had worked rock-drills	1.15	6.65	20.7	38.6	47.0	64.8
Excluding men who had worked rock-drills	1.15	6.2	6.3	14.8	32.3	61.4

It is evident that rock-drill work is entirely responsible for the recent great increase in the mortality of Cornish miners between the ages of 25 and 50. Of the extra deaths due to rock-drill work, only about 40% can be attributed to work in Cornish mines, the rest being nearly all attributable to work in the Transvaal. Of 17 cases in which the duration of rock-drill work in Cornwall only was ascertained, the average was 8.4 years, and of 47 cases in which the duration of work in the Transvaal only was ascertained the average was only 4.7 years. From these figures, and the fact that 98% of those who had worked drills in the Transvaal only, as compared with 89% of those who had worked in Cornwall only, died of lung disease, it would seem that rock-drill work in the Transvaal has been more dangerous than in Cornwall. This is also the general opinion among Cornish miners. Both in Cornwall and in the Transvaal the drills have been generally worked without water-jets or other appliances for preventing dust. In consequence of this all the holes have been dry in "rising," and a certain proportion in driving. The quantity of dust produced by a rock-drill in boring a dry hole is well known to all who are connected with practical metalliferous mining.

In the Transvaal the white miners, in their haste to earn money, appear to push forward with development work regardless of the dust from blasting, whereas in Cornwall they usually allow the dust from a blast to settle before returning to work. There seems also to have hitherto been very little regard for ventilation in most Transvaal mines. Probably, therefore, a great deal more dust is inhaled in a given time in Transvaal than in Cornish mines.

There is no good reason for supposing that the dust produces its effects on the lungs in other ways than mechanically, by its hardness, sharpness and insolubility. No indications are known to us that any poisonous chemical influence is exerted on the tissues. The effects seem to be the same whether the dust is from granite, flint, ganister, quartz or hard sandstone. The element of tubercular infection is evidently superadded to the damage done to the lung tissue by dust. Apart from this damage the tubercle bacillus would be unable to gain a footing. But where the effects of dust end, and those of the tubercle bacillus, or possibly other micro-organisms, begin, it appears to be difficult at present to say. The great difficulty in obtaining post mortem examinations in Cornwall has hindered further investigation of this point.

The argument in favor of the theory that inhalation of stone dust is the cause of the excessive mortality from lung disease among Cornish miners may be summed up as follows: (1) Metalliferous miners are undoubtedly exposed to the inhalation of dust from hard stone; (2) The inhalation of such dust is known, from experience in other employments, to cause phthisis and other lung diseases; (3) No other suggested cause associated with work in metalliferous mines is capable of explaining the excessive

liability of metalliferous miners to lung disease; (4) The miners most exposed to dust are most liable to lung disease.

PREVENTION OF MINERS' PHTHISIS.

As miners' phthisis and the associated lung diseases which render metalliferous mining unhealthy, are due to the inhalation of dust from hard stone, the problem of preventing these diseases evidently resolves itself into that of the prevention of dust inhalation. In what way can this be best accomplished? Four different methods, each of which may have its place, suggest themselves: (1) To use respirators to filter off the dust. (2) To prevent the giving off of dust into the air. (3) To carry it away when given off. (4) To arrange the work in such a way that dust, when given off into the air, is avoided by the men.

The practical difficulties connected with the use of respirators are, we fear, very serious. In the first place men wearing respirators cannot communicate with one another. Respirators also cause a good deal of discomfort, particularly during work in a hot place. The breathing is nearly always more or less impeded if the respirator fits tightly; and if the dead space inside the respirator is of any size the breathing must always be abnormally deep or frequent. The depth and frequency of normal respiration are unconsciously so regulated with the utmost nicety as to keep the percentage of CO_2 constant at about 5.5 to 6% in the air cells of the lung. Hence it is clear that since the dead space inside a respirator is charged at the end of each expiration with air containing about 6% of CO_2, the breathing must be deeper or more frequent in order to establish compensation.

For all these reasons the temptation to men to remove their respirators is extremely strong. But a further objection arises from the fact that respirators—particularly those most easily worn—very often fit so badly that after a short period of use nearly all the air breathed leaks in at the edges, and is not filtered at all. To overcome all these difficulties satisfactorily under actual working conditions underground appears to be very difficult, and the end in view can, we think, be usually obtained more easily in other ways. Respirators, such as wet sponges, ought, however, always to be used by miners who have for any reason to go for a short time into very dusty air.

A very great deal can be practically attained by preventing dust being given off into the air, and this method of dealing with dangerous dust ought, we think, always to be adopted when possible. The most urgent problem is evidently that presented by the conditions under which rock-drill men work, and the terrible mortality among these men. The dust from rock-drills boring dry holes certainly cannot be dealt with by increased ventilation, but it is well known that no dust is given off from wet holes. If, therefore, all the holes were wet no dust would be given off. The only way of wetting holes driven in an upward direction by an ordinary percussion drill is to use a jet of water. If a jet is directed upwards into the hole parallel to the bit of the rock-drill the giving off of dust is completely prevented. When, however, the hole is more than a foot or two in depth the water fails to reach the cutting edge, behind which a ring of very tenacious mud is apt to be formed. When the bit is withdrawn, at the end of the operation, its expanded end catches in this ring of mud, and may thus cause much delay. For this reason, and also because a very powerful jet involves considerable consumption of water, it is better not to try to wet the hole for more than a few inches up. Hence, either a plain jet directed obliquely, or a scattering jet or spray, should be employed. Some of the coarse dust certainly falls out of the hole in a more or less dry state, but the fine dust is effectively damped.

The simplest method of supplying water for the jets is to carry an iron water pipe along the level, or up the rise, along with the air pipe, and to take the water from the end of this pipe to the jet through a piece of armored rubber hose of narrow bore. In many places, however, water cannot be conveniently obtained, or the pressure may be insufficient. To overcome this difficulty we have used at Dolcoath a steel cylinder, holding about 12 gallons or more, which is placed in some convenient positions out of the way of blasting, and not far from the drill. The cylinder has three taps, of which one, provided with a funnel, is for filling with water, one for connection with the compressed air pipe, and one for connecting with the flexible armored pipe for carrying water to the jet or spray. On closing the filling-tap and opening the compressed air-tap the water is driven to the jet.

The pressure is sufficient to enable the jet to be used at points up to about 100 ft. above the cylinder in a rise. To obviate risk of the cylinders bursting or being injured by rough usage they were stoutly made and tested to a pressure of 600 lbs. per sq. in. The water used may be conveyed to a large vessel placed beside the cylinder, for convenience in refilling. One filling will last for a shift. A nozzle, or spray, with an opening of about 1-20 of an inch in diameter is sufficient, and it is well to have a filter of fine copper gauze inside, to obviate inconvenience from accidental blocking. The spray nozzle we have employed is of a kind commonly used for garden syringes, etc., and is so arranged that a rotary movement is imparted to the water before it issues. What would otherwise be a plain jet is by this means converted into a scattering jet or spray.

It is obvious that many other arrangements for producing sprays or jets are possible. Experience alone will show what methods answer best under the actual conditions underground. A number of jets and sprays, connected either with water pipes or the cylinders just described, were provided some months ago at Dolcoath. Much difficulty has, however, been experienced in persuading the men to use them, objection being raised by many of the men to the splashing of drops of water. The slight inconvenience from this cause outweighs in the minds of these men the known risks of breathing dusty air. The trouble experienced in obtaining the co-operation of the men has considerably retarded the general introduction of jets or sprays, and their improvement or simplification to meet practical requirements.

It appears to us that the prevention of dust inhalation by rock-drill men is such a very important and urgent matter that the use of percussion drills in mines without water jets or other efficient means of preventing the dust from being given off, should be definitely prohibited once for all; and we have no doubt that the great majority of both miners and mine owners would strongly support legislative interference in this direction.

A further problem is presented by the dust produced by blasting in ends and rises where rock-drills are employed. Just after a blast the dust near an end is so thick that it is often impossible to see a candle a foot away. In Cornwall the men usually arrange so as not to return for a considerable time; but in the Transvaal mines it appears to be common for both Kaffirs and white men to return almost at once, in spite of the dust. For dealing with the dust from blasting in an end or rise the following plan, devised by Mr. William James, Underground Agent at Dolcoath, has been found very effective. At the mouth of the level a piece of 6-in. iron pipe, provided with a side-tap, is let into the ordinary 2-in. iron pipe for carrying the compressed air to the drill. Before blasting this is filled with water through the side-tap from a cistern after the compressed air has been turned off. Immediately after the blast the compressed air is suddenly turned on. The water is thus driven along the pipe, and a mixture of finely divided water and air is discharged from the open end, which is pointed towards the face which has just been blasted. By this means the dust is entirely cleared from the last 30 or 40 ft. back from the fall, and the air will be found entirely clear immediately after. If a ventilating pipe has been carried forward about as far as the open end of the compressed air pipe, any dust which has been carried outwards beyond the reach of the water can be quickly carried off. This plan implies scarcely any trouble, and no extra apparatus, except the piece of 6-in. pipe and the water pipe for filling it. The rock blasted is also thoroughly wetted, so that no dust is produced in shoveling it. The water partially washes out from the air any nitrous fumes which may be present, but of course not carbon monoxide; and for this reason, if no other, a ventilating pipe is desirable in cases where the level or rise has been driven more than a few fathoms from a shaft or winze. If a jet of compressed air is used for driving air along the ventilating pipe it should be turned so as to extract air after blasting, while during work in the end or rise it is better to blow air in. Or a separate air jet with a large sized nozzle (about 0.2-in. opening) may be employed for rapidly extracing air after a blast.

Although men working in stopes in English metalliferous mines, or driving by hand, are not nearly so much exposed to dust as rock-drill men, and enjoy good health for 25 or 30 years, yet they do suffer considerably after the age of about 40, the dust which they inhale being chiefly produced by shoveling dry ore or stone and by blasting. The drilling in the stopes is, however, almost all done by hand in English metalliferous mines, and there is consequently much less blasting than in the Transvaal, so that conclusions drawn as to the health of English metalliferous miners working by hand, must not be taken to apply also to South African conditions.

The dust produced in moving the ore and conveying it to the shafts could be prevented entirely if all the material moved could be kept damp. By taking a little trouble in this respect, and using buckets of water or other means whenever possible, individual miners could do a great deal to prevent the formation of dust. The dryness of the ore depends also on the dryness of the atmosphere. When a stope is very freely ventilated with fresh dry air it inevitably becomes very dry. On the other hand, in deep mining abundant ventilation is absolutely necessary in order to keep down the temperature, to say nothing of the dust and smoke from blasting. Endeavors ought therefore to be made to keep the air moist and at the same time ventilate as freely as possible.

Where metalliferous mines are very dry the use in intake air-ways of sprays similar to those employed in coal mines would greatly assist in keeping the air moist. One of the chief recommendations of the Transvaal Medical Society for the prevention of miners' phthisis is that "dry mining should, as far as possible, be converted into wet mining." While we entirely concur with this recommendation we ought also to point out that wet mining in the Transvaal would, under present [illegible] greatly increase the risks from ankylo[illegible] satisfactory sanitary precautions could at [illegible] introduced for preventing the spread of [illegible] for the dryness of these mines ankylost[illegible] all probability have proved extremely tr[illegible] now, as there is every reason to believe [illegible] bers of infected men are at work.

We have little doubt that if once it h[illegible] recognized that the excessive mortalit[illegible] liferous miners in England as compared [illegible] ironstone miners, is due almost entirely [illegible] of stone dust, remedial measures will be [illegible] will at any rate greatly reduce the [illegible] metalliferous mining into a relatively he[illegible] Powers already exist for dealing with [illegible] the Metalliferous Mines Regulation Act; [illegible] ance with the provisions of this act we th[illegible] rules, which are of course subject to th[illegible] consent of the Secretary of State before the[illegible] ly binding, should be drawn up by the m[illegible] every metalliferous mine, for the carrying [illegible] in such a way as to reduce to a minimum [illegible] stone dust by the various classes of men employed.

MUNICIPAL NOTES IN GERMANY, HOLLAND AND BELGIUM.

(Editorial Correspondence.)

Seventeen days is but as a moment to devote to a journey from England to France, Switzerland, Germany, Holland and Belgium; and when one tries to combine ordinary sightseeing with calls on professional men and visits to engineering works, the period mentioned seems all the more inadequate. If, therefore, the notes in this and my two former letters* from the Continent seem fragmentary the reason may readily be understood. It is only fair to add, however, that what I lacked in time was in many respects more than made good by the excellence and courtesy of my voluntary guides, who greatly facilitated my visits to engineering works, and at the same time helped me to see the best of the objects sought out by the tourist.

I seize this opportunity to impress upon young engineers, and particularly the students in our engineering schools, the value of a good command of both French and German. Business or pleasure may take the engineer to Europe at any time, in which case the ability to read and speak French and German may prove invaluable. Even if one is so fortunate, as was I, as to fall into the hands of English-speaking people, there will still be many limitations to the opportunities of an engineer who speaks nothing but English. The ability to read the languages named, even if they can not be spoken, is of great value to the engineer-traveler, as he is certain to accumulate many pamphlets and books printed in these languages. But entirely aside from trips to Europe, which to the student or struggling young engineer may seem too much like Castles in Spain for serious consideration, a reading knowledge of French and German is of great value. This is fully recognized by our best engineering schools; but many students, particularly those who have been denied or foolishly deny themselves the advantages of a broad general education before beginning their engineering studies, belittle and neglect the instruction in French and German which is at their disposal.

At Hamburg I devoted the most of my time to the water purification plant and the refuse destructor, each of which ranks among the largest and best of its kind in the world.† To describe these plants in detail here is of course out of the question, but their main features and present status may be outlined in a few words. Mr. Rud. Schroder, Engineer in Charge of the pumping machinery and filters of the Hamburg Water-Works, and Mr. Adolph Bergeest, Assistant in direct charge of the filters, showed me the filters, and Mr. Schroder also served as interpreter at the refuse destructor.

The water supply of Hamburg is pumped from the Elbe to settling reservoirs, further purified by slow sand filters, then pumped again. The works stretch along for some distance, which we covered in a small railway car, propelled at a good rate

*On Paris, Eng. News, June 2, 1904; and on Zurich, Carlsruhe, Frankfort-on-Main and Wiesbaden, Eng. News, June 9, 1904.

†The population of Hamburg in 1900 was 705,000. Only a part of the refuse is burned.

of speed by two men with poles. When there is a suitable wind the car is moved by a sail instead of by poling. Nearly 21 hours sedimentation is afforded by the settling reservoirs. The normal capacity of the low-lift pumps which supply the reservoirs is about 75,000,000 U. S. gallons a day.

The slow sand filters remain essentially as they were when built in 1893-7, after the cholera epidemic, except that four beds, with different floor and drainage systems, have since been added. There are now 22 beds, each with a surface area of 7,500 sq. meters, or a total of some 35 acres. There is a set of sand washers for each group of four beds. The washers have vertical ejectors and are much cheaper in operation than the drum washers originally used. A portable mono-railway, operated by a rope, pully and horse, is used for conveying dirty sand to the washers, and when washing is in progress one bed is always being refilled, thus saving the handling of the sand. When the beds are covered with ice they are cleaned by means of a scraper and bag, drawn across the beds, beneath the ice, by means of ropes.

Investigations for a supplementary ground water supply are now being made. It is hoped that 13,000,000 U. S. gallons per day can be developed. The wells would be about 160 ft. deep and the water is artesian. By mixing this with the filtered water the latter would be rendered cooler and more agreeable generally.

The refuse destructors at Hamburg include 36 Horsfall cells and now receive the wastes from a population of 420,000. The refuse from the other portions of the city is still disposed of on land. An electric overhead crane is used for lifting the boxes from the collecting wagons and dumping them on the feeding platform. An air-blast is employed for forced draft. The cinders are raked into cars, pushed to and cooled by water jets in a special quenching tower, then pushed further, tipped into a hopper, crushed, mechanically elevated, and screened. The dust from the screens is drawn to a receiving chamber and deposited by water jets. The heat from the destructors is utilized to drive engines of 260 eff. HP., which generate electricity for power used at the destructor and for transmission some three-fourth miles to a sewage pumping station equipped with four 40 eff. HP. pumps. The addition of another station is proposed.

This refuse destructor is the first and only one where I have been shown pyrometers, and where I have seen the monthly operations of the plant recorded in the form of diagrams.

Shower baths are provided for the workmen at the destructor, and once in two weeks their clothes are sent across the street to the municipal disinfecting station. Mr. Otto Uhde is chief engineer and manager of the refuse destructor.

Before leaving Hamburg I secured a view showing some elaborate iron poles and arms for supporting trolley wires over the street and arc lamps over both the street and the sidewalk. The view also shows the careful way in which the roots and lower trunks of young shade trees are guarded. On the left may be seen a row of tables forming a part of one of the outdoor restaurants so common on the Continent.

SUPPORTS FOR TROLLEY WIRES AND ARC LAMPS ON A STREET IN HAMBURG, GERMANY.

IMPRESSIONS AND OBSERVATIONS IN BERLIN.

When I had completed my work at Hamburg I had been abroad more than two months, and in every city visited I had had a definite program, generally one which occupied most of my time in seeing municipal work and professional men. I resolved to see a bit of Berlin with no more definite plan than to gain some general impressions of this capital city and perhaps a few suggestive details from observations in streets and public places.

The trip from Hamburg to Berlin takes about 3½ hours by good trains. Although able to remain in the city less than two days, I was well repaid for the visit.

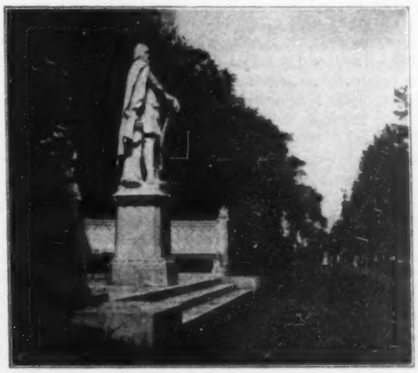
I had heard much of the grandeur and beauty of the street known as Unter den Linden, but I was greatly disappointed at its actual appearance. The two rows of lime and other trees bordering the great central walk are crowded and irregular, and many of the trees are undersized, the smallest ones apparently having been crowded in to make up for the deficiencies of the larger ones. On each sidewalk there is a row of young but promising trees. The whole street is broad, is lined with fairly good buildings, many of which are notable either for the governmental purposes they serve or the royalty or nobility they house.

But while disappointed in the Unter den Linden itself, I passed on through it, by means of one of the old city gates, to a spacious park, known as the Tiergarten, through which runs a truly noble avenue. Along this avenue, known as the Sieges Allee or Avenue of Victory, has been erected a double line of monuments of most unique and attractive design. Each monument consists of a marble hemicycle seat, in front of which is a marble statue of a Prussian ruler. Each hemicycle is adorned with the busts of two men who were prominent during the reign of that particular monarch, and is decorated according to the style in vogue in his reign. The diameter of each platform and its enclosing seat is about 33 ft., and the statues are about 120 ft. c. to c. on each side of the avenue. The two rows of statues are about 300 ft. apart, and the street space between is occupied by a broad asphalted central driveway, and a bridle path and foot walk on each side. The paths and foot walks are shaded by a double row of trees on either side. Hedges parallel to the walk cut off the avenue from the heavily wooded park. The grass plots between the groups of statuary are adorned with shrubs and gay flowers. The white marble, standing out in bold relief against the dark green background, affords an excellent illustration of the effectiveness of good statuary well located in a wooded park.

The Sieges Allee seems to me to be more effective than any comparable avenue in Paris, because its sculptural embellishments are more serious in purpose and dignified in realization than those seen in Paris, and have at the same time at least as good a setting. The Sieges Allee, however, contains an extended historical composition in marble and so possesses a unity such as is rarely possible in so extended a group of statuary. It suggests possibilities and difficulties for other capital cities, including our own Washington, which I will not venture to discuss in this letter. I did not see as much of Berlin as of Paris, but from what I saw and from the map of the city, I am confident that Berlin has done far less than Paris in developing a rational street plan. The German capital, however, appears to be superior to the French in rapid transit facilities, particularly on account of its belt lines of steam railways. I found time to ride for some miles on the Electric Elevated and Underground Railway, which in some respects is similar to the underground road in Boston. Berlin has surface cars operated by both overhead and underground trolleys. In fact, nowhere since I left New York have I encountered such a network of trolleys and so much difficulty and danger in crossing the streets as in Berlin. More underground railways seem to be needed. Omnibuses are to be found in Berlin, and there are many cabs.

Two unique features of the Berlin cabs are their taxameters, now quite generally in use, and the means to regulate the drivers at the railway stations. As to the latter, a cab cannot be obtained without first securing from an official at the station exit a metal ticket embossed with a number. The color of the metal indicates the character of the cab you wish, and the number corresponds with that on the cab. A vast amount of confusion and annoyance is thus avoided.

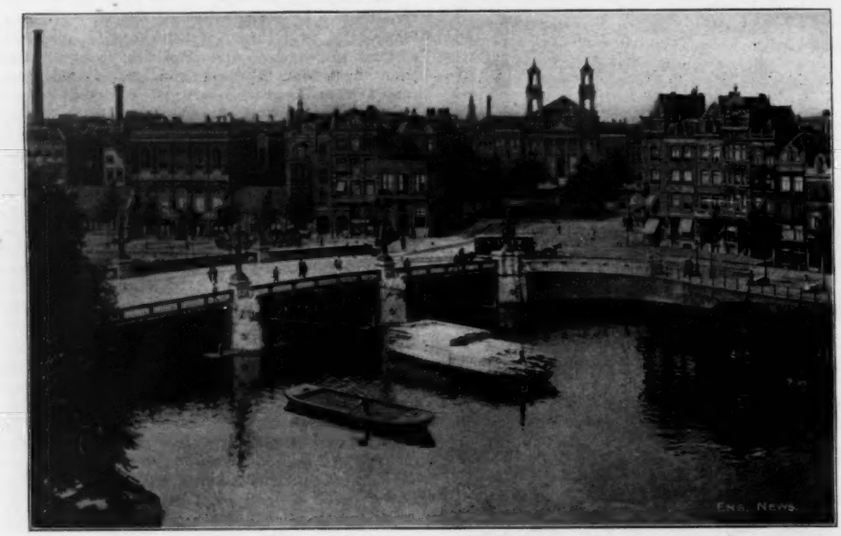
The taxameter may be described as a device for protecting those acquainted with the streets of the city, for imposing upon those who are not, and for fleecing the unwary of either class. It is really a modified cyclometer which registers fares in pfennigs and marks and distances in kilometers, the latter in totals for the day. The local guide books say that the rate of fare in taxameter cabs



View Showing Part of One Side of Sieges Allee, Berlin, Germany.

is 50 pfennigs (half a mark or 12½ cts.) for the first 800 meters (say one-half mile), and 10 pfennigs for each additional 400 meters. My best German and gestures combined would never induce a cab driver to set his taxameter further back than to indicate 50 pfennigs. That sum I think the guide books should be corrected to give as the minimum fare, and of it no one need com-

plain, since, if one or two persons ride two kilometers, or 1¼ miles, they need pay only a mark, or 25 cts.; but between passengers the drivers have a way of forgetting to set the taxameter back to the minimum fare. If there are more than two persons, the taxameter may be readily adjusted to register at another rate of fare, and there are different colored cards on the register to indicate which rate is being registered. The legal rates of fare are plainly printed on the taxameter, and at night the cab lamp can be turned on so as to light the register. All disengaged cabs are provided with a label marked "Free." This label is attached to the taxameter in such a way as to throw the latter out of registration when the tag is exhibited.



CANAL AND BRIDGE IN AMSTERDAM, WITH CHURCH OF MOSES AND AARON IN THE DISTANCE.

In the Tiergarten, a large park, I saw several street washing machines for cleaning asphalt. Each wagon was drawn by two horses, was provided with an open circular water tank, with a sprinkler beneath, and for a washer a revolving rubber squeegee was attached behind like a broom on a street sweeping machine. The squeegee consisted of a wooden roller, fitted spirally with sheets of rubber, which projected some 2 or 3 ins. beyond the wood.

A GLIMPSE OF AMSTERDAM.

I stopped in Amsterdam just long enough to see some of its many canals and bridges and to be impressed with the good architectural effects obtained by combining plain and glazed tile bricks of different and often brilliant colors. The pavement, usually of brick, was very uneven, though otherwise good, and the unevenness may be due to the soft foundation one finds in Amsterdam, which makes it necessary to build the houses on piles. Besides bricks, I noted small stone block and some asphalt pavement, and I observed that the streets were in good repair and notably clean. One of the photographs which I obtained in Amsterdam is reproduced herewith to show a main canal and bridge, with buildings beyond.

The accompanying sketch shows the trolley bow used in Amsterdam in place of the ordinary trolley pole. The sides of the bow curve around and down until they meet the poles, then cross over, each to the opposite pole, thus forming, with a horizontal cross-piece, a support for a large gilded car line number.

A DAY IN ANTWERP.

Half of my day in Antwerp was very pleasantly spent with Mr. Adolph Kemna, Director or Manager of the Antwerp Water-Works Co. Mr. Kemna has not yet lost faith in well-filtered surface waters, even though many Continental, and particularly German engineers, are so hot in the pursuit of ground waters, nor is he ready to admit that slow sand filtration need be or can economically be displaced or even supplemented by ozone treatment. I did not have time to visit the Antwerp works, but learned that the Anderson system of treating the water with scrap iron in revolving tanks, prior to filtration, is still in use. When the biological conditions have been unfavorable to good results with slow sand filtration, Mr. Kemna has used sulphate of alumina with good effect. Recently he has made provision for adding ferric salts to the water after it has received ferrous salts from the Anderson treatment. The ferric salts are produced by passing the water through a stationary tank containing iron or steel turnings, into which air is blown. The water treated is a mixed surface supply containing iron and peaty matter, and is subjected to sewage pollution from the tidal Scheldt. To avoid the tidal pollution the whole supply is drawn from a tributary of the Scheldt, once in twelve hours, during a period of 40 minutes. The water has twelve hours' sedimentation before it receives the iron treatment and is filtered. Mr. Kemna is a chemist and biologist, and imparted much information and many suggestions regarding the character of public water supplies.

Antwerp has many wide streets and boulevards, and the area of Belgian block pavement must be enormous. I was impressed with the desirability of reducing the width of the paved roadway by adding to the already liberal space devoted to trees and walks, and at the same time saving money to provide a smoother paving material.

Sketch of Trolley Bow on Street Cars in Amsterdam.

Electric wires in Antwerp are placed overhead on the tops of high latticed columns or on trestles built on the tops of the houses.

One of the most notable features of Antwerp is the track elevation of the State Railway for several thousand feet outside the main station. The track is supported on a handsome masonry viaduct, with its successive lateral sections built of stone arranged to represent the different geologic ages. The main streets are crossed by fine masonry arches, the ends of which are marked with towers. Smaller towers, or pinnacles mark buttresses on the sides of the viaduct, and break the monotony of the masonry railing as seen both from the street and from the railway train. Combined in the general design of the viaduct are two masonry towers for the railway water supply.

BRUSSELS.

The morning of my last day on the Continent was spent with Mr. Victor J. Van Luit,* Inspector (we would say engineer) of water-works distribution and Director of "La Te[illegible]gie Sanitaire:" We visited one of the under[illegible]nd sources of water supply, located in a State f[illegible]t near the city, and consisting of some miles [illegible]infiltration galleries, from 100 to 160 ft. belo[illegible]e surface. The other source of supply is near [illegible]battlefield of Waterloo, and is even more exte[illegible]laterally. All water is metered in Brussels, a[illegible]he supply to the city fountains is utilized ag[illegible]and again by means of electric pumps place[illegible]neath the fountains.

Brussels owns gas works, and [illegible]a Horsfall refuse destructor which has been i[illegible]for about a year. The city has some large [illegible]ers, which are exhibited at times like those i[illegible]Paris. The sewage is discharged untreated int[illegible]e Scheldt, much to the regret of Antwerp, as [illegible]be understood from the foregoing reference[illegible]the water supply of that city.

I saw in Brussels what I have [illegible]g believed should be provided in many if not m[illegible]American cities, and what I have never seen elsewhere; numerous shelters for waiting street car passengers. Most of these shelters were well lighted, provided with seats, and fairly commodious. I did not learn whether the shelters were provided at the initiative of the company or the city.

M. N. B.

Brussels, Belgium, May 18, 1904.

*73 Avenue Michel-Ange, Brussels.

MODIFICATIONS OF THE PLAN OF THE NEW CROTON DAM.*

By William R. Hill,† M. Am. Soc. C. E.

The responsibility of the engineer in charge of constructing dams and reservoirs is but vaguely appreciated by the public. In view of the many disastrous failures that have occurred, due to faulty plans and poor construction, it is made imperative for the engineer to exercise his best powers to insure proper and substantial structures. There is, perhaps, no other field of engineering that develops in the course of construction so many new conditions and unexpected obstacles, and when the engineer finds it necessary to make radical changes in the plans, even though involving heavy expenditures and subjecting himself to severe criticism, it is his bounden duty to make these changes.

The writer had the honor of being Chief Engineer of the Aqueduct Commission of the City of New York from Jan. 1, 1900, to Oct. 14, 1903. During his incumbency the new Croton Dam was under construction.

The purpose of this paper is to explain, as briefly as possible, the original plan of this structure, and the imperative necessity of its modification, and to answer a general demand made upon the writer that would seem to indicate a very widespread interest in these notable changes. Had the work continued under the original plan it might have resulted not only in the failure of the structure itself but have been the cause of immeasurable loss to this great city of its supply of water in addition to an appalling destruction of life and property.

The boroughs of Manhattan and Bronx, of an estimated population of 2,200,000 are dependent almost entirely upon the Croton River for their supply of water; in fact, they have no other supply, except the comparatively small quantity (20,000,000 gallons per day) from the Bronx and Byram Rivers, small as compared with 290,000,000 gallons, the present daily consumption of these two boroughs.

The natural flow of Croton River in dry seasons was judged insufficient to supply the city as early as 1835, now more than 60 years ago, so Croton Lake, of a capacity of two billion gallons, was then created by building the old Croton Dam. Since then, from time to time, six other reservoirs, having an aggregate capacity of 40,000,000,000 gallons, have been built on the principal tributaries of the river, above the lake, for the purpose of collecting water in wet seasons, to be discharged into the lake as required for use. The city has no auxiliary supply, and no lakes or rivers that could be used as such in case of an emergency, hence an accident to a reservoir might result in so great a loss of water as to cause a water famine, truly styled one of the world's greatest disasters.

The new Croton dam is located about 37 miles from the Central Park reservoirs. It is on the Croton River, about 2½ miles below the old Croton dam. Its purpose is to enlarge Croton Lake, increasing its capacity from two to thirty-two billion gallons and its length from 5½ to 19¼ miles. The old dam will be submerged, as the flow line will be raised 36 ft.

The clearing of this great basin for the reservoir, 20 miles in length, was in itself an extraordinary undertaking, embracing the clearing of all timber, the removal of three villages, numberless buildings, farm houses and cemeteries and the abandonment and reconstruction of

*Paper read before the American Water-Works Association at St. Louis, Mo., June 8, 1904.

†Consulting Engineer, 242 Sixth Ave., Brooklyn, N. Y.; Late Chief Engineer, Aqueduct Commission.

railroad tracks, telegraph and telephone lines, highways and bridges.

The work of constructing the new Croton dam commenced Oct. 1, 1892. It calls for a very large quantity of masonry. In fact, there will be no less than 800,000 cu. yds. In this connection it may be of interest to note that it will be the largest block of masonry in the world, excepting the Egyptian pyramids.

There are three distinct features of the dam, the spillway at the north end, the main stone dam crossing the valley and the embankment at the south end. The spillway wall is built on the side of the valley, curving up stream from the stone dam; it is 1,000 ft. long, 10 ft. high at the end and 150 ft. high at its junction with the dam. It is rubble masonry, faced on the water side with cut stone in regular courses and the lower side is in steps of large blocks of stone. A channel for the overflow is excavated in the rock back of the wall leading down to the river below the dam. The main stone dam, according to the original plan, was to be 600 ft. long, extending from the spillway to the foot of the slope at the south side of the valley, thence an embankment and core wall 568 ft. long was to continue to the end, making a structure 2,168 ft. long.

The main stone dam is rubble masonry, faced on both sides, above the surface of the ground, with cut stone in regular courses. It is 297 ft. high from the deepest point of the foundation, which is 131 ft. below the bed of the river. Its greatest width at the base is 206 ft. and the width at the top is 20 ft. At the junction with the core wall according to the original plan it had a height of 230 ft. For the purpose of reaching a point where the core wall would have a lesser height, the Aqueduct Commissioners on Sept. 16, 1896, on the recommendation of the former Chief Engineer, authorized him to extend the main stone dam 110 ft., in substitution of the embankment and core wall but even at the point thus reached the core wall would have a height of 200 ft. This extension materially increased the cost of the structure.

The embankment was to be 30 ft. wide at the top, with sides sloping in the ratio of 2 horizontal to 1 vertical. The lower portion of the inner slope to a height of 16 ft. below the crest of the spillway, to be paved with stone, 18 ins. thick, laid dry, upon 12 ins. of broken stone, and on the upper part of the slope to a height 12 ft. above the crest of the spillway, the paving stone was to be 2 ft. thick, upon 18 ins. of broken stone. The core wall in the centre of the embankment was to be 4 ft. higher than the crest of the spillway, 6 ft. wide at the top and increasing to 18 ft. at a depth of 136 ft., then same width to the base. The core wall was to be 200 ft. high at the junction with the stone dam and 90 ft. high at a gate house that is built in the embankment, 290 ft. from the stone dam. The high end of the core wall had been built in a wide pit, that was a necessary excavation for the end of the stone dam, which was 164 ft. wide at the base, while the core wall was but 18 ft. at its base. The slope of this pit extended southerly along the line of the wall for a distance of 150 ft., thus the core wall at its highest end was not built in a narrow trench below the surface of the ground as is usual in ordinary cases.

The bed rock on the north side of the valley is gneiss and the structure is founded upon it for a length of 1,200 ft. The character of the rock then changes abruptly from gneiss to limestone and this extends southerly beyond the end of the structure. Although the contract drawings, upon which the contract was based, indicated "hard rock" at a depth of 75 ft. below the bed of the river, yet it was found necessary to excavate the foundation pit to a depth of 131 ft. before finding a firm foundation of hard rock. The character of the stone removed varied greatly; in places it was compact, then diversified by masses of stone broken up by open, eroded and mud-filled seams, and in places there were belts of disinfegrated limestone. During the progress of the excavation water flowed freely through the seams and several open caves were found in the rock. In consequence of this great additional depth, it was also necessary greatly to increase the width of the base of the dam. Thus again the cost was materially increased because of the additional quantity of excavation and masonry.

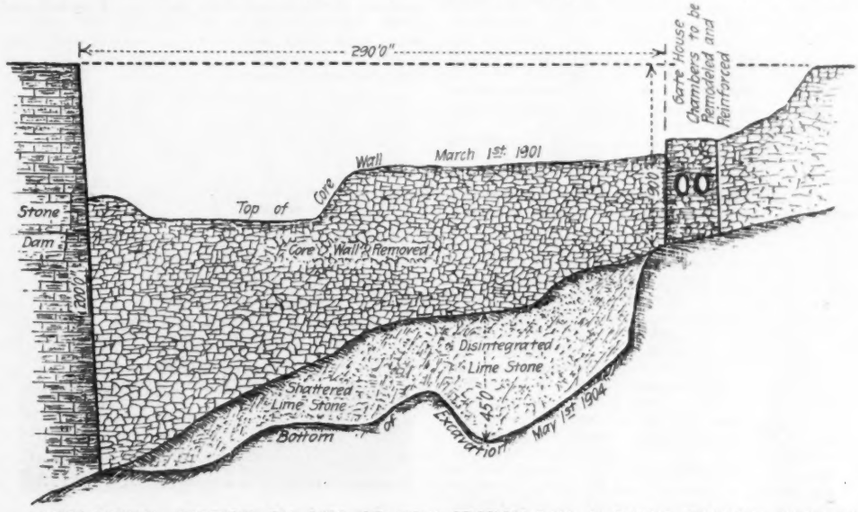
Before the writer assumed the responsibility of this work, the foundation of the stone dam had been completed to the surface of the ground and the core wall had been completed, excepting the stretch between the stone dam and gate house, which lacked about 60 ft. of its height.

In the spring of 1901, this core wall cracked in five places within a length of 100 ft. This caused the writer to believe that some serious disturbance had taken place, as in his opinion the cracks were too close together to be caused by contraction. After close study of the conditions, there was no conclusion to be arrived at except that there was a fundamental weakness here, and, therefore, it would be unsafe to proceed with the work. This close study brought to view objectionable features of the plans of the embankment and core wall, the most conspicuous of which were three. First the excessive height, narrow base and unstable foundation of the embankment; second, the great height of the core wall, and, third, the double means afforded the water to reach the core wall.

To take up the first, the embankment: it was to be 250 ft. high, and only 650 ft. thick at the base. This section would be not only about 40% higher than any heretofore built, but in comparison with other high embankments its base was narrow for its height. As an example, the Amawalk dam, which forms one of the upper Croton reservoirs, while only about half the height, 85 ft., has a base even wider than that of this embankment of unprecedented height. And further, this embankment was hazardous because of the unstable nature of its foundation. It was founded over a great refilled pit, which was 360 ft. wide at the top, 170 ft. at the base and 70 ft. deep; this pit was a necessary excavation for the foundation of the end of the stone dam, which was 164 ft. wide at the base as before stated. It would be impossible to refill this pit as compactly as original ground, hence the safety of the reservoir was dependent not only on an embankment of a problematic section, but this problematic section rested upon an unstable foundation.

The second of the objections: The core wall of this embankment was 200 ft. high and with no lateral protection or support from original ground whatsoever, as the artificially placed earth on each side of the wall had the height of the wall itself, 200 ft. Considering the height of the wall, and this in artificially placed earth, it could but be an experimental structure, inasmuch as it would be about twice the height of any heretofore built.

The third objection: The double means afforded the water to reach the core wall, is another serious objection, as the water by starting at the end of the embankment in the reservoir and following between the face of the stone dam and the embankment would inevitably reach the core wall. It would be impossible to puddle or otherwise compact the embankment against the dam to prevent this, as



LONGITUDINAL SECTION ON AXIS OF NEW CROTON DAM, SHOWING CHANGES MADE IN CONSTRUCTION.

settlement would surely follow in any embankment of this great height. This objectionable feature here exists because of the combination of a stone dam and an embankment, while it could not exist in either a continuous stone dam or, on the other hand, a continuous embankment and core wall. As to the second channel by which the water could reach the wall there is also little doubt, for it would be afforded freer access through the refilled material of the great pit, than it would have in ordinary cases, where the wall below the original surface of the ground is in a narrow trench and protected by original soil. It would be useless to consider any proposition to increase the width of the embankment, because the means afforded the water to reach the core wall along the face of the dam would always remain; this is a most dangerous feature, as the core wall would not have sufficient weight or strength to resist the pressure of the water that would come against it.

A fourth objection might here be stated, namely, the permeable and light character of the earth of which the embankment was made, but even with the best of material, an embankment so constructed would be insecure.

Thus it will be seen that the safety of this reservoir was dependent not only upon an embankment of a problematic section, resting upon an unstable foundation, but also upon a core wall of phenomenal height, unprotected and unsupported by original soil and attended with the greatest of all possible risks, that is the means afforded water to reach the center of the embankment against the core wall.

Such a structure can not be regarded as anything but an experiment. It is abnormal and unprecedented in all its dangerous features. The engineer might apply in vain to science for aid in computing the efficiency of such a structure; he could get no light, for he could find not even the slightest guaranty of safety in a structure so built.

The failure of this embankment might not only create a devastating flood in the valley below, but also cause a current above, of such irresistible velocity, as would destroy the earthen part of the old Croton dam, thus at once cutting off the supply of water to the city until the old dam could be repaired and in addition postponing indefinitely the time when the city could have the additional supply of water which the enlarged reservoir was to furnish.

Thus the writer was thoroughly convinced that a change in the plan of the structure at this point was necessary. Thereupon he recommended to the Aqueduct Commissioners that this entire section of the embankment and core wall to the gatehouse be removed and the stone dam extended in its place. But while maintaining that the conditions allowed of no other conclusion, he recommended that a committee of three engineers be appointed to pass upon a question of so vital and widespread importance.

The Commissioners after personal investigation agreed in this and appointed a committee of expert engineers consisting of Messrs. J. J. R. Croes, Past President of the American Society of Civil Engineers; Edwin F. Smith, Chief Engineer of the Schuylkill Navigation Co., and Elnathan Sweet, former Engineer of the State of New York. The committee, after making an investigation, reported unanimously recommending this extension of the stone dam to the gatehouse.

The general public will no doubt feel that great weight has been added to these conclusions by the concurrence of the eminent engineers Prof. William H. Burr, occupying the Chair of Engineering of Columbia University, and Mr. Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment of the City of New York; both of whom had been asked by Mayor Low to investigate and report thereon. On April 16, 1902, the Aqueduct Commissioners resolved to remove the embankment and core wall and to continue the main stone dam to the gatehouse.

The estimated cost to complete the embankment and core wall under the original plan was $145,233, while the preliminary estimate of the cost to remove the embankment and core wall and extend the main stone dam is $635,700. The difference $490,467 being due to this modification, yet there will be a further increase because of the condition of the natural foundation of the core wall, as hereinafter described. In considering this estimate one should not lose sight of the fact that there has been a loss sustained of about $80,000, the cost of that part of the core wall that had to be thus abandoned.

In March, 1903, the core wall having been removed, it became apparent that the embankment and core wall would have been undermined and destroyed if completed under the original plan. The core wall was found to be resting upon limestone that in places was completely disintegrated to the form of loose sand and other portions in the process of disintegrating were more or less hard, the softer part being in such a condition that it could be easily crushed by the hand to the form of sand and would absorb water as freely as would a sponge. The hardest of this stone was full of eroded, open and mud-filled seams, the existence of mud being evidence that these seams had acted as passageways for water. Under date of April 1, 1903, Prof. Burr, who had concurred in the condemnation of the wall, reported to Mayor Low as to the foundation as follows:

It is most fortunate that the core wall has been removed so as to disclose the actual situation and thus remove what would have been a source of gravest danger to the completed embankment structure as originally planned.

Prof. J. E. Kemp, of Columbia University, and Prof. J. J. Stevenson, of New York University, both geologists,

were retained to investigate the locality affected. They reported that the conditions were deserving of very serious consideration and that in certain locations the material was found to be so soft that in their own words it "runs with water like sand." Under their advice this loose and disintegrated rock has been removed to the depth of 75 ft. below the base of the core wall, for it is only at this great depth that a suitable foundation for extending the dam has been found. The removal of this soft rock and replacing it with masonry has again materially increased the cost of the structure. The work of building this masonry is now in progress.

Another important change of plan is that of the gatehouse, above referred to. This gatehouse is located in the embankment outside of the core wall. It is well up on the slope of the valley, its base being about 100 ft. higher than the bed of the river. The substructure of this gatehouse is described as follows: It has four water chambers, 74 ft. deep and about 12 ft. square. Two on the southerly side of the structure are to control the flow of the water in the old Croton aqueduct which passes through this gatehouse. The other two on the northerly side, are to control the flow of water direct from the reservoir to the old aqueduct below the dam. These two chambers are connected with the reservoir by three brick inlets, 10 ft. in diameter. And they are to hold water to a depth of 54 ft., yet the outer walls (which are enclosed in an artificial embankment) have a uniform thickness from the base to top of but 8 ft., while safe construction demands that they should be about four times that thickness at the base.

These walls which had been built to a height of 50 ft., would not have sufficient strength to resist the water pressure that would come against them, and their destruction might result in a great loss of water from the reservoir and the demolition of the embankment, by the rush of water in falling a height of 150 ft. to reach the valley below. On Dec. 18, 1902, on the writer's recommendation, the Aqueduct Commissioners approved a plan providing for the reinforcement of these walls.

The preliminary estimate of the cost to construct the dam under the original plan was $4,150,573. This will be increased to about $6,400,000. The great increase in the cost of the work is due principally to the four above described additions and modifications namely: the extra depth excavated under the main stone dam, the first extension of 110 ft. of the main stone dam, the extension of the main stone dam necessitating the removal of the embankment and core wall and lastly the additional excavation necessary for the foundation of the last extension. Some idea of what these changes have necessitated may be gained from the consideration of but two items, that of the amount of earth excavation which will be trebled and that of the amount of masonry which will be increased from 550,000 to about 800,000 cu. yds. The value of the work done to March 1, 1904, is $5,363,000.

This most important of all structures to this great city, upon which its welfare would be almost wholly dependent, had to be mantled with all possible safeguards against its destruction. Thus the writer being brought face to face with the one paramount necessity, that of the safety of this structure, was left no alternative but to modify the plan.

THE USE OF STEEL FOR COAL MINE TIPPLES.*

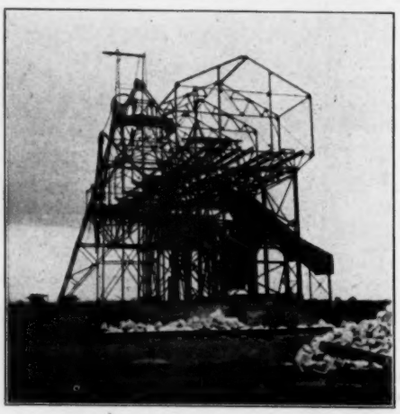
By Geo. S. Rice, M. W. S. E.†

Ten years ago the use of structural steel in building mine shaft-towers or head-frames had been somewhat extensive in other countries on account of the comparative scarcity of lumber, but here, with the exception of a very few coal tipples in Pennsylvania, and a few head-frames in the Michigan copper country, there were practically none constructed of steel. The use of steel had not been seriously considered by western coal operators for several reasons. It was expensive as compared with wood, both on account of the structure itself, and on account of good foundations required; as tipples built of wood are quite often supported merely on wooden blocking. It was thought that steel would not be durable, being exposed to powder smoke from the mine, and frequently to sulphurous gases from burning "dirt" dumps on the surface. At that time stationary screens were used and the strains to which the tipple was subjected were light and easily taken care of by ordinary wood framing. Finally the attention of the various structural building concerns had not been directed to this business.‡

About ten years ago, at the No. 1 shaft of the Spring Valley Coal Co., of Illinois, the tipple was burned and the brands falling into the shaft set fire to the curbing and adjacent entries. The shaft caved in, and the company was put to heavy expense to sink another and to recover the mine. It was concluded to put up a steel tipple and ensure against a repetition of this loss. This tipple was designed and built by Pittsburg parties and was, the writer thinks, the first steel coal mine tipple built west of Pennsylvania. About the same time there began to be a demand in some of the markets for better screened coal than furnished by the straight bar screens, then in use. Some of the companies experimented successfully with the use of shaking screens. These screens, as now made, are usually divided in two sections as nearly even as possible, and driven by eccentrics on the same shafting, 180° apart. The weights are not great, two to three tons for each section empty and as much again when loaded, but as they have a stroke of 4 to 6 ins. and make 140 to 110 double strokes per minute, according to design, the pull and thrust at either end of the stroke is considerable. It is the shifting load of coal that makes it impossible to more than partially balance the pull and thrust of the eccentrics.

The wood frames from which the shaking screens were hung when introduced were quite inadequate to transfer the strain to the foundations below. The same was true of the first steel frames, for the structural builders did not appreciate the effect of the lively shaking, and in the case of one light steel structure in Indiana, the screens are said to have "kicked the legs off the main tower frame" in a very short time.

Early in 1898, the writer designed a steel tipple for the Cleveland mine, erected the following spring, and which was the first departure from wood in Iowa. A tipple for Cardiff No. 1 shaft was designed about the same time, and was the second built of steel in Illinois. Since then, especially in the last two or three years, steel tipples have multiplied rapidly in Illinois and the adjoining states, not to speak of the large number built in the eastern coal fields. During this period, the companies with which the writer is connected, have built three more of steel. None of the five structures built by these companies have been duplicates or in fact resembled one another. This has not



Perspective View of Cardiff Coal Tipple.

been altogether a process of evolution, but rather the result of varying conditions.

One feature in the physical characteristics of mines that has an important bearing on the general design of the tipple structure, is whether or not the roof is of such nature that surplus rock must be hoisted and dumped. In the long-wall mines of Illinois, for every four or five cars of coal a car of rock refuse must be hoisted and disposed of. In the thin vein room-and-pillar mines, there is much less to hoist, and in the thick veins none at all, since, if any is produced, there is ample room to store it below ground.

In the matter of screens the practice is very varied. Some mines have a bar screen only. Others, bar screens for lump coal and shaking screens for egg, nut, and pea coal. Revolving screens, so much used formerly, have generally been discarded. But the majority of operators are now putting in shaking screens for all sizes of coal in new tipples. As regards mechanical arrangement, there may be found single deck or double deck screens, and these hung by pendulating rods or in some cases mounted on wheels. In this direction standardization would be useful to builders, but its practicability may be doubted, taking into account the variety of coals, whether hard or soft; the purpose for which the coal is to be used, whether for stocking or immediate use, and for locomotive or stationary engines or domestic use.

The greatest difference in tipple construction is due to the style of cage used, whether a self-dumping or a rigid cage. A self-dumping cage is one in which the platform of the cage is hinged. The hinge or axle is below the platform, either at the center or a little off center. The car is held on the platform by clamps of various forms. When the cage in hoisting nears the point of tipping, a roller on the side of the platform enters a curved channel track which tips the platform and its car, causing the latter to dump its load. These are used in a large majority of the tipples in the middle and south part of Illinois and also in Indiana. A subdivision is the hopper cage, in which the hopper tips in similar manner to the tipping platform. Coal is dumped into the hopper, when at the bottom of the mine shaft, either directly from pit cars or (in one example in Illinois) from the screens discharging into bins. The hopper cage is like the skip of the Lake Superior iron region,* and while its mechanical simplicity and lower cost recommends it, any dumping of soft coal breaks it to pieces more or less, and the use of the hopper cage makes two trips of couplings as against one where the pit car is brought to the top. There are other objections, but this is the most widely used one in this part of the country where the largest percentage of lump coal obtainable is desired. At present there is but one example of the hopper cage in Illinois.

The plain or rigid cages are the oldest form, and, while used in most of the very small plants, are also used in some of the largest and most modern plants. Other things being equal, and provided there is plenty of room on the upper landing, the plain cage allows a larger dumping capacity than the self-dumper. There are several reasons for this: 1, the self-dumper does not always dump the coal out of the pit car thoroughly, particularly if the coal is wet, thus causing a delay till it is shaken out; 2, any delays in shifting railway cars or in changing the flaps of screens or a temporary lack of loaded pit cars at the shaft bottom, stops hoisting; with the plain cage, if dumping ceases a minute or two, hoisting may still continue, or if hoisting stops from lack of loaded pit cars below, dumping can continue until the supply on the tipple is exhausted. These little savings in time amount to considerable in the course of a day. 3. The self-dumper is much more liable to disarrangements, particularly with deep hoists, and pit cars are very apt to jerk loose when the platform tips and lodge in the chute. Nevertheless, the writer thinks that for shafts not over 300 ft. deep, with large pit cars and no refuse rock to hoist, the self-dumper is both cheaper to install and cheaper to operate and a very large capacity can be obtained.

The rigid cages may be classified as follows: 1. Single deck; 2, double deck; 3, single deck with two cars side by side; 4, single deck with two cars end to end. They are listed in order of their capacity for handling coal. The first is the oldest form, and is still the most commonly used. The second is used at only three or four coal mines in the middle west, all in northern Illinois. The third is used abroad more or less, but is not in use anywhere in the west. It is certainly very inferior to the fourth plan, which is in use at two mines in northern Illinois.

Coal shafts of any importance are always arranged with two hoisting compartments; the hoisting engines have either one winding drum or two keyed to the same shaft, and the cages (whether riding or self dumping) are hung in balance; so that when one is at the top the other is below. The arrangements for receiving and dumping the pit cars at the tipple, are various, and have an important bearing on the general design of the tipple structure. They are of two general classes:

1. The tipple has a level floor. The loaded pit cars are run off the cage by hand, and are pushed to the tipping point. After dumping, the car is shoved back onto the cage; or in the better type of tipples of this pattern the empty car is pushed around the shaft, and when the next cage arrives at the top with its load, the empty car is pushed against the loaded car, shoving the latter off the cage and taking its place. In the more improved tipples, through the aid of certain devices, the loaded car is helped off the cage by a slight and momentary tipping of the rails of the cage. This is the prevailing style of tipple in Iowa, Missouri and Kansas; it has a capacity of 1,000 tons of coal per day of 8 hours, with pit cars of fair size (holding 2,400 and 2,600 lbs.), and the shaft not over 300 ft. deep. Such a capacity would require from four to six men on the dumping floor in addition to the weighman and those employed on the railway cars. If a considerable quantity of rock had to be handled, it might require two more men to obtain the tonnage mentioned. Double-deck cages for this form of dump building would not be of advantage, as the pit cars could not be handled fast enough to cause a gain, the hoisting capacity being in excess of the dumping capacity.

2. The dump building has a floor arranged to give certain grades to the tracks, so that the pit car runs by gravity to a cross-over tipple; then after dumping its load, is righted, and the next car followed by means of levers opens the locking horns long enough to let the now empty car through. The horns then spring back and catch the incoming loaded car. The empty car runs down a sharp incline through a spring switch and up a short steep incline, which reverses the direction and turns the car into a track which has a down grade to a point back of the shaft. The car here runs on to a transfer platform by which it is carried sideways up an incline which brings it in line with one compartment of the shaft. When the next loaded car has been brought up by the cage, a steam ram pushes the empty car against the loaded car, shoving the latter off and leaving the empty car on the cage ready to be lowered. There is a duplicate arrangement for each of the two compartments of the shaft. A variation in this plan is obtained by the use of an automatic car haul to carry the pit car up to the proper level

*Abstract of a paper read before the Western Society of Engineers, Chicago, May 11, 1904.

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‡A coal mine tipple on the line of the Southern Indiana Ry. was illustrated in our issue of Feb. 25, 1904. A steel shaft-house for the Oliver Iron Mining Co. at Ely, Minn., was described and illustrated in detail in our issue of Nov. 19, 1903.—Editor Engineering News.

*Engineering News, Nov. 19, 1903.

for pushing the car on the cage; with this arrangement the grade back of the shaft can be made so steep that the steam team is not needed.

With a shaft not over 200 ft. deep, pit cars holding one ton or more, and using single deck cages with one car, there is no difficulty in obtaining a capacity of 1,400 tons in eight hours; with pit cars holding 1½ to 2 tons, 1,600 tons capacity can be obtained. When shafts are more than 200 ft. deep, to obtain a large tonnage, it is advisable to hoist two cars at one time. This may be accomplished with double deck cages, with which the time gained over "single decks" is the difference between hoisting 6 or 7 ft. (the distance between decks) and in hoisting the depth of the shaft. With cars holding 1½ tons of coal in shafts not over 200 or 300 ft. deep, the double-deck cage with either of the arrangements spoken of, should hoist as much as 2,000 tons in eight hours, and with cars holding 2½ tons, 2,400 tons per day should be obtained. There is material advantage in having the two cars on one deck of the cage, as this saves at least three or four seconds needed to change decks. With this arrangement from 2,200 to 2,400 tons capacity can be obtained with cars holding 1½ tons, and a larger amount with larger cars. With any arrangement, the capacities are reduced by increased depths of shaft.

The capacities mentioned may not appear to be very large, as compared with those at the mines of central and southern Illinois, with the simpler self-dumping equipment. It must be noted, however, that the conditions are more favorable in the latter field. The pit cars used hold from 2½ to 3½ tons; the depth is generally less than 300 ft., and in some of the largest mines not over 150 ft., and with no refuse rock to hoist and dump; outputs of 1,600 to 1,800 tons per day are not unusual and on spurts are run up to considerably over 2,000 tons.

As shaking screens cause some vibration in their supporting frame, it is now the usual practice not to connect this frame to the main building, since the railway scale beams are customarily placed in the weigh room on the tipple floor and any considerable vibration interferes with accurate weighing. The dumping of the cars causes some vibration, but it is not continuous, as with the screens.

The greatest working strain thrown on the structure is in hoisting the cages. These, with their load and the hoisting rope, weigh from 3 to 4 tons for the simpler kind, and from 6 to 8 tons for cages holding two cars. The hoisting engines are usually made with a considerable surplus of power, so that in starting to hoist, they are apt to pick up the cage with a jerk. In this way the strain is from two to three times the dead load. Another great strain that may be thrown on the tower structure with rigid cages, comes from the pound of the cages as they land on the "rests" at the floor level. This may be very heavy with double deck cages, if the engineman is not careful and this contingency must be allowed for. In self-dumping cages this pound is avoided, but, on the other hand, there is considerable horizontal strain due to the reaction in tipping and dumping, which must also be taken care of.

The most difficult problem, however, is to take care of the horizontal strain produced in hoisting. The hoisting engine is placed more or less away from the shaft, so that the rope makes an inclination of 25 to 75° from the horizontal. The engine should be placed a considerable distance from the shaft, not only with a view to safety from any fire originating in the mine and coming up the shaft, and also to be away from any settlement (unless the foundations can go to rock), but chiefly because it is less trying on the hoisting rope. When the rope is inclined so that it sags slightly, it has a certain amount of elasticity due to this. The limiting inclination is that at which the rope does not require rollers for its support, and an inclination of about 40° is usually good.

With wooden tipples, it is customary to run the "engine brace" from the engine foundation to the frame carrying the sheaves. In hoisting, the resultant of the strain bisects the angle which the vertical part of the rope makes with that part running to the engine. In an extreme case, however, produced by an over-wind where the detaching hook is not used, or by any other kind of accident where the cage lodges in the upper part of the tower, the line of the resultant would be directly from the sheave to the engine drum. The engine brace then takes the full strain and if strong enough, prevents the overturning of the tower. Most steel tipples have followed the plan of running the engine brace from the sheaves to the engine foundation, though many of them are not designed strong enough to break the hoist rope before yielding. The writer always advises the use of detaching hooks, but in calculating the ultimate strength of the structure he assumes double the strength of the rope, to allow for any possible chance of the hooks not working.

With wood structures that are not tied down to heavy foundations it is necessary that the resultant should fall between the engine brace and the tower; in other words, within the base. This is not the case with steel structures, but some designers have not realized this, and have followed the lines of wooden structures. The writer has accepted for the Cardiff No. 2 tipple a novel design by Mr. Andrews Allen.* In this tipple the tower proper has an A-frame symmetrical with reference to the center line of the shaft. When the full strength of the tower is developed it is necessary to depend on the weight of the foundation under the back legs (those further away from the engine) to prevent overturning, and this is allowed for in the design of the foundation. The tower proves very stiff in operating, with practically no vibration when a cage is being hoisted.

A considerable variation is caused in designing tipple structures according to whether the engine is placed directly behind the shaft, in which case the sheave wheels are side by side; or whether the engine is placed at the end of the shaft, in which case the sheaves are either one above the other, as in the Cardiff No. 2 mine, or are placed so as to almost touch, with a slight inclination in the line of the shaft. The majority of builders place the engine back of the shaft because it is simpler to construct the head frame in that way. The writer prefers to place the boiler house alongside of the railway track, so that coal for the boilers can be unloaded from the cars direct into the tower when desired. Then to place the engine house close by requires end hoisting.

In the matter of details for the steel structure, the writer has these suggestions to offer:

(1) Built-up pieces should be as simple and compact as possible. All lattice work to be avoided. The cross-section of the members should be such that they can readily be painted on all surfaces. Angles or other pieces constituting a member should be offset where necessary to avoid small spaces or else fillers used.

(2) Rod braces should not be used. All light braces should be angle bars.

(3) Angles, plates and webs of any shapes should not be less than 5-16-in. thick, no matter how small the strain may be.

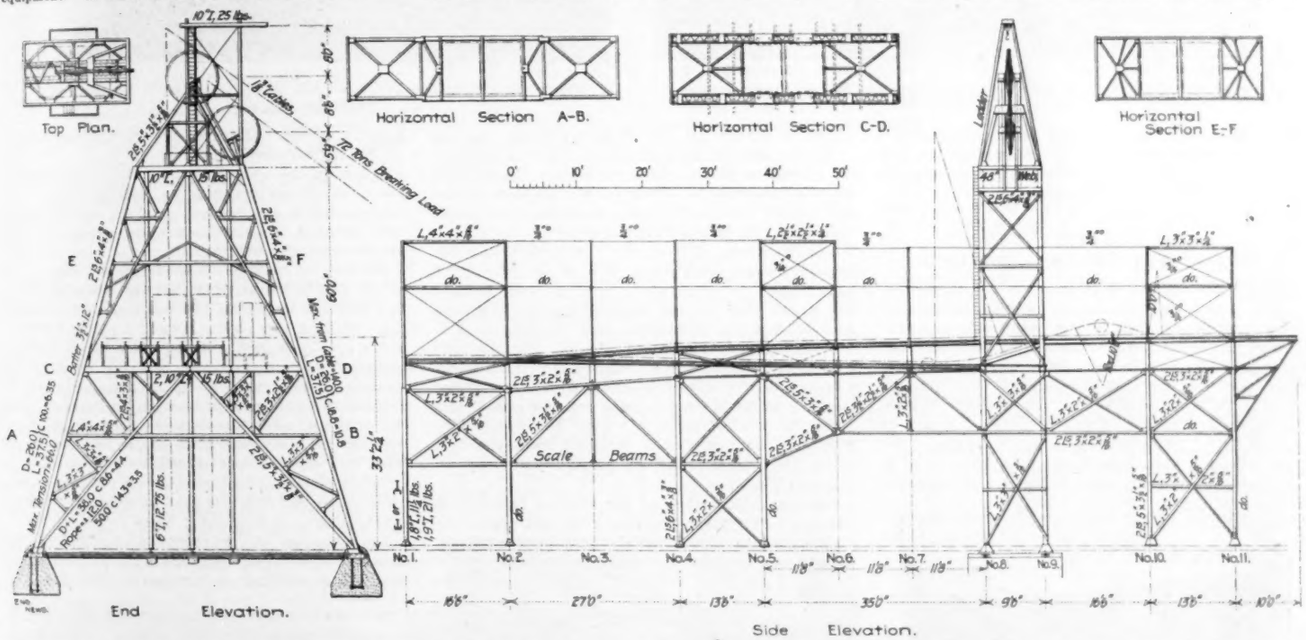
(4) All main parts of the tower should be kept as far back from the shaft as possible, in view of a fire originating in the mine, and to keep the foundations away from the shaft.

(5) The structure should be shipped in as large sections as possible, properly riveted, but field bolts should be used in erection on the ground. This saves expenses, and if the structure is to be taken down in future for moving elsewhere, it is of advantage. The writer has found no difficulty from the field bolts getting loose.

(6) As responsible structural building concerns are in position to give the best design suited to their shops for the least money, provided they have full knowledge of the requirements, it is advisable for the local operator who may submit his own plans for bids, to invite suggestions for improvement.

As to the relative merit of steel as compared with wood construction, there are two questions usually raised: (1) Is steel durable under the conditions at the mine; and (2) is the greater cost of the steel structure justified? There is no question but that steel is more durable than wood. In this part of the country it has been put to a test of about ten years without appreciable weakening. In the matter of first cost, a steel tower and tipple will cost about twice as much as a wooden structure, and whether or not the operator is justified in employing steel is more open to argument in small plants. In some places a shaft rarely has sufficient field to last over 10 or 12 years, and the average lifetime of a wooden tower is sufficient for this. On the other hand, if a steel structure is used and bolted together there is a large salvage value. A fire might originate in the wood tower and set fire to and destroy the mine, and in this event, under the best of circumstances, the mine would be out of business for a couple of months and thus cause a loss that would probably be far greater than the cost of a steel tower. That such fires are not infrequent can be seen by looking over the state mine reports, and during the past year three large tipples have burnt down in Illinois alone. As to mines of large capacity, it will not admit of argument that steel should be employed, and the writer believes that the feature of fire protection is sufficient to justify the employment of steel in all shaft tipples, small or large.

The A-frame tipple at the Cardiff mine, men-



GENERAL ELEVATION AND CROSS-SECTION OF STEEL COAL TIPPLE WITH A-FRAME TOWER FOR THE CARDIFF COAL CO., CARDIFF, ILLINOIS.
Andrews Allen, M. W. Soc. E., Designer. Wisconsin Bridge & Iron Co., Milwaukee, Wis., Builders.

*Contracting Engineer, Wisconsin Bridge & Iron Co., Monadnock Block, Chicago.

tioned in the above paper, is shown in the accompanying cuts. There are two A-frame bents spanning the shaft, the shoes of each bent being connected by the tie-bars embedded in concrete. The main bracing of each bent consists of two triangular or A-frames instead of the usual form of X-bracing, and this arrangement leaves large central openings for handling the mine cars, etc. The engine house is at the side, this instance are spaced 6 ft. c. to c.; and it will be observed that the rollers do not run loose on shafts, but that the shaft runs in bearings, thus materially reducing the friction, and effecting more perfect lubrication.

Fig. 2 shows the lower, or supporting belt resting upon the rollers. Bolted to this belt will be seen the blocks that serve to support the carrier belt and to give it a trough shape.

used costing far less per foot than [illegible] and made belts required to stand the wear [illegible] ent to the one belt systems. Moreover it is [illegible] ined that the power plant of the two-belt sy[illegible] need not be so great as for the one belt sy[illegible] of equal capacity, due to the fact the roll[illegible] riction of rollers having shafts running in be[illegible] is much less than the rolling friction of r[illegible] loose on the shafts. Furthermore there is [illegible] ficulty in

FIG. 1. ROLLERS OF THE RIDGWAY "TWO- BELT" CONVEYOR.

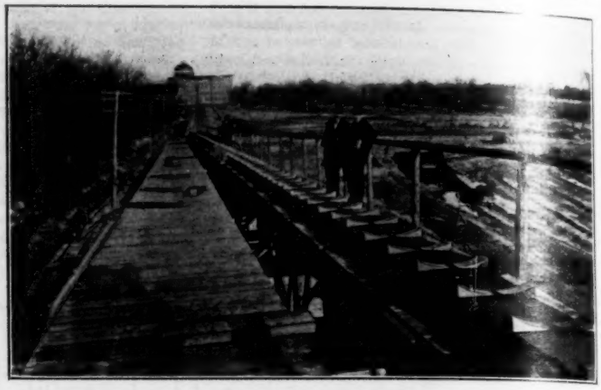


FIG. 2. BELT WITH TROUGHING BLOCKS READY TO RECEIVE CARRIER BELT.

and the legs of the A-frame bents are anchored down to resist any overturning moment, so that in case of overwinding or other emergency the rope will break before any serious strains are put upon the tower.

THE RIDGWAY "TWO-BELT" CONVEYOR.

When an endless belt is used for conveying material it is necessary to trough the belt. This is commonly done either by using sets of three supporting rollers (one horizontal and two inclined), or by using coned rollers. In either case there is wear on the belt that is more or less severe. Where coned rollers are used the bottom of the belt is subjected to the scouring action of the roller, which is greatest near the edges of the belt where the surface velocity of the roller is obviously greater than at the center of the belt.

Fig. 3. The Ridgway "Two-Belt" Conveyor, Showing Absence of Deflection.

Where the three-roller system is used, the belt in time wears out along the line of intersection of the horizontal roller with the inclined roller, that is where the belt is bent. To overcome these causes of wear the "two-belt" system was invented by Mr. John J. Ridgway.

Perhaps the clearest way to illustrate the "two-belt" system is to show photographs of the successive steps in the installation of a "two-belt" conveyor.

Fig. 1 shows the supporting rollers, which in

Fig. 3 shows the two belts traveling together over the rollers, the upper belt carrying the load of gravel or stone. This photograph is particularly noteworthy as it shows the absence of deflection or waves commonly seen where a single conveyor belt passes over rollers.

Fig. 4 shows a complete conveyor plant designed for handling sand, gravel and stone for the largest concrete plant ever erected, namely the plant used by the Sand Filtration Corporation of America in building the Washington Filtration System, Washington, D. C. The concrete mixers of this plant are designed to mix 1,250 cu. yds. of concrete per 10-hour day. A storage capacity of 6,000 cu. yds. of stone and gravel and 4,000 cu. yds. of sand is provided, as shown in Fig. 4. The material is dumped from the belt along any desired line, or at any point, by an automatic tripper.

Having a clear idea of the general features of the two-belt system, the side view and cross-section shown in Fig. 5 will be readily understood. It will be seen, in the upper cross-section, that the belt, which is troughed so as to carry the gravel or stone, does not run in the trough on its return, but is supported on the lower rollers and it in turn supports the belt to which the troughing blocks are fastened. The side view shows that each belt has its own head pulley at each end of the conveyor, and that a chain running over sprocket wheels makes both belts travel precisely at the same speed, thus insuring complete absence of slip of the carrier belt on the troughing blocks. Near each head pulley is a troughing roller that lifts the carrier belt off the troughing blocks so as to obviate any rubbing at the moment the two belts separate. Fig. 6 shows the carrier belt and the chain gearing.

A question that will be asked by any one particularly interested in belt conveying will be the question of first cost of plant. Will not a two-belt conveying system cost much more than a single belt system? To this the reply is made by the manufacturers that the two belts used in this system cost no more than the single belt used in other systems, because not only is each belt of lighter weight but machine made belts are

keeping rollers lubricated on the inclined shafts of the three-roller system.

When, in the course of time, the carrier belt of the two-belt system requires renewal the cost of its renewal is obviously less than would be the case were a heavier and more expensive belt needed for this purpose.

Another advantage claimed for the light belts of the two-belt system is that the fewer the plies in a belt the longer its life when subject to bending. When a belt passes around a pulley its outer fibers are in tension and its inner fibers in compression; the thicker the belt the greater the stresses in the extreme fibers, consequently the greater the tendency of one ply to "creep" upon the next ply, and thus in time to break the bond between the successive plies of the belt. To minimize this effect a belt should be as thin as possible, consistent with strength—an object which is attained in the two-belt system where the load is divided between two light belts.

Summing up the advantages claimed for the two-belt system as compared with the single belt systems of conveying, we have: (1) The conveying system is lighter; (2) it is self lubricating and has dust proof bearings; (3) as a consequence of the two foregoing factors, less power is required; (4) when the carrier belt requires renewal the cost of a new belt is approximately one-half as much as the renewal of the best type of single conveyor belt; (5) the bending strain due to the load on the belts is distributed so that both belts run with practically no sag between the rollers; (6) in consequence of the foregoing factor the life of both belts is longer than with

FIG. 4. THE RIDGWAY "TWO-BELT" CONVEYOR HANDLING CONCRETE MATERIALS, WASHINGTON, D. C.

other systems in spite of the fact that lighter and cheaper belts are used.

The manufacturers of the two-belt system of conveying are the Ridgway Belt Conveyor Co., 29 Broadway, New York city.

THE METER SYSTEM IN CLEVELAND.*

By Edward W. Bemis.†

No city has ever set so many meters in so short a time as has Cleveland during the past two years. The number in use increased 21,686 during 1902 and 1903, 96% of which increase was in ⅝-in. meters. There were only 121 of these in use during December, 1901, but in December, 1903, there were 20,850. It was high time two years ago for this attempt to do what should have been done long before. A comparison between Cleveland and Milwaukee illustrates, with remarkable clearness, the results of metering.

The population of Milwaukee increased from 177,000 in 1887 to 300,000 in 1901, 70%, while that of Cleveland grew with but slightly greater rapidity, having increased 77%, or from 232,000 to 411,000 in the same fourteen years. The number of connections in use had increased more rapidly in Milwaukee than in Cleveland. In the former city it had grown from 13,243 to 43,386, or 238%, while in Cleveland it had only grown from 22,655 to 55,130, or 142%. The number of meters, however, had increased in Milwaukee eighteenfold, or from 1,729 to 31,114, while in Cleveland the number had increased only twofold, or from 1,525 to 3,344. Behold the results in pumpage:

The daily pumpage in Milwaukee increased only from 20,000,000 gallons in 1887 to 24,000,000 gallons in 1901, or 20%, while in Cleveland it increased from 22,000,000 to 69,000,000 gallons, or 213% in the same period. The daily consumption per capita declined in Milwaukee from 113 gallons in 1887 to 80 gallons in 1901, but in Cleveland it rose from 96 gallons to 169 gallons in the same time. In other words, the consumption of water in Cleveland, which was nearly one-third less per day per capita in 1887, was over twice as much in 1901 as in Milwaukee.

On assuming the superintendency of the Water Department in September, 1901, the writer of this paper began, with the able co-operation of Mayor Johnson, a campaign of universal metering. In January, 1904, 25,030 meters were in use on 42.5% of the 58,852 services. The average daily consumption in 1903, was 62,010,650 gallons, or 7.5% less than in 1901. It was 142 gallons per capita instead of 169 gallons. If the remainder of the city is metered and a careful examination is made of the possible leakage in street mains, the consumption ought to be reduced to 100 gallons. It cannot be made so low as in many cities because of there being no source of water supply except to a few factories, aside from the City Water-Works, and because about 40 gallons per day per capita are used for business purposes and in large hotels.

The average increase of water used every three years from 1882 to 1900 had been 32.9%, and during the three years ending in 1900 it had been 38.7%. Since the city was growing rapidly and was very prosperous during the following three years, it is reasonable to suppose that the consumption, without house meters would have increased another 32.9%, and would have averaged about 80,000,000 gallons per day last year, or 37,000,000 gallons —i. e., 43% more than was actually pumped. The pumpage the first four months of the current year has been slightly less than for the corresponding period of 1900, while the average increase for the four years in this city since 1880 has been 40%, and during the period 1896 to 1900 it was 47%. This does not take into account the slip of the pumps, which has been carefully measured by Mr. Cole with his pitometer, although only approximate results can be reached. It appears, however, that owing to the use of newer and more improved pumps the slip in 1900 was about 10% and in 1903 about 5%.

In order to popularize the meters they were set impartially on every street radiating from certain centers selected as representative of different classes of the population. It was thus possible for the more prudent housekeepers to realize the advantage of the meter, and to create public sentiment that should meet the opposition of the

*A paper read at the Annual Meeting of the American Water-Works Association.

†Superintendent of Water-Works, Cleveland, Ohio.

more wasteful. Neither the flat nor the meter rates, however, were changed. The flat rate is $3 for the first three rooms or less, and 50 cents for each additional room, together with $2 for every bath tub and every water closet. On all flat rate bills of $1.50 for six months there is a discount of 15%. Nothing is charged for lawn unless where there is over 66 ft. frontage. Thus an eight-room house with one bath and closet would be charged $9.50 per year. The meter rate is 5½ cts. per thousand gallons, or 40 cts. per thousand feet for all consumers, large or small.

Of the 38 cities of the United States of over 100,000 population, only two, Detroit and Washington, charge less on the meter basis than do we for ordinary house consumers, and both of these cities pay a considerable revenue to the water departments for water used for city purposes, while the Cleveland Water Department does not receive a cent, although it furnishes a large amount free for public use. Five other cities of the 38, viz., Chicago, Toledo, Detroit, Indianapolis and Buffalo, have a lower rate for large consumers. But the scale is so adjusted that in most of these places any Cleveland firm would pay higher rates than it now does with us. In the two most marked exceptions, Detroit and Buffalo, the city pays the water department a large sum annually for water used, which is also true in the case of Indianapolis.

Until last November few objections were heard to the rapid increase of meters in Cleveland. Three causes have since somewhat changed this condition:

(1) Some political conditions not at all connected with meters, but which have led to an opposition in the Council to administration measures.

(2) An epidemic of typhoid fever, due in very large part to the lake water, visited the city in early part of this winter. As this was unfortunately coincident with the discussion of the meter question, the amusing idea arose, and was for a short time widely held, that the meters were the cause of the typhoid. Fortunately the introduction in March of a new water supply through a tunnel running four miles out into the lake has already almost entirely stopped the typhoid and the scare connected therewith, but those desirous of prejudicing the people against the meters have introduced the matter of

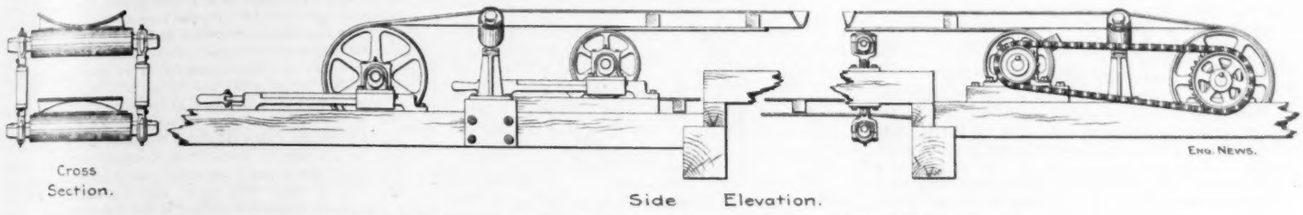


FIG. 5. CROSS-SECTION AND SIDE VIEW OF THE "TWO-BELT" CONVEYOR SYSTEM.

Fig. 6. Showing Chain Drive of the "Two-Belt" Conveyor.

health in a new form by claiming that the screen embedded in our meter, the Trident, collects organic sediment and especially small fish and allows them to putrify and injure the water. Investigation has shown that no animal matter is to be found on these screens, except that on less than one meter out of a hundred a small fish may lodge in the course of a year. Usually, however, this lessens the flow of water, and the water department is notified and removes the fish. To avoid this difficulty in the future, screens are being placed at the outlets of the tunnel and of the reservoirs with a ⅛-in. mesh, which will probably prevent all such trouble hereafter. The experience of other cities is solicited as to how fine a mesh it is practicable to use.

It is well known among water-works superintendents that there is scarcely a committee of experts that has ever reported on water purification that has not suggested meters in order to lessen the cost of a purer supply. It is obvious that this would not be done if these experts, from Maine to California, had any evidence of the unsanitary character of meters.

FREEZING OF METERS.

A third cause of objection to meters this year has been the freezing of many meters and metered services. This condition has not been peculiar to Cleveland. From water-works superintendents all over the North have come reports of similar conditions. The Weather Bureau records show this to have been the coldest winter since the establishment of the Signal Service. The effect of this on the water department was greatly aggravated by the almost entire absence of snow since the thaw in January, which left the ground exposed to the cold. During the last few years our tappers have been instructed to refuse to tap the street mains for new services until the trench from the main to the curb was 5½ ft. deep, but a large proportion of the old services of the city were originally laid only 4 ft. deep, or have become only that deep on account of the grading down of the street along the line of the service pipes. No special trouble, however, had occurred from freezing prior to the past winter, when the frost on some streets went down from 5 to 7 ft. Four causes then contributed to the large amount of trouble, as follows:

(a) The condition of temperature and snow, above referred to.

(b) The shallow service pipe setting, also referred to above, which not only existed in the streets but also inside the premises of the owner.

(c) The knowledge of a meter being in place led many families to refrain from letting the water run night and day to prevent freezing, as had been customary where the danger from freezing was thought to be great. Our water rates are so low, being only 1 ct. for 200 gallons, that I announced through the papers that one could permit one quart a minute to run constantly at an expense of only 2 cts. a day, or $1 for the 50 days when the most of the freezing occurred, during January and February. Many misunderstood this, and allowed a large stream to run, and are now claiming that they should not be charged for it, as they did it by what they thought was the authority of the department. Many others, however, did not let their water run constantly, and their service pipes were so poor that they froze in the unusual winter weather.

(d) The meters themselves, in many cases, were not set properly in the sewer pipe setting, which was briefly explained to the American Water-Works Association last year.* The meter hitherto, when placed outside and not in brick vaults, was enclosed in 4 ft. of sewer pipe 15 ins. in diameter on the inside. Risers came up from the surface pipe to the meter, the top of which was only 18 ins. from the iron cover. Resting on the top of the meter was a loose wooden cover. Within the entire 4 ft. of sewer pipe there is no earth, but merely an air chamber.

With 979 settings in such sewer pipe in the winter of 1902-3 not one froze, but during the past winter 1,226 out of 10,423 set in sewer pipe, or 11.7% froze, as compared with 136 out of 4,483, or 3% set in brick vaults and 165 out of 9,727, or 1.7% set in basements. To be sure, this is not a fair comparison, at least as between sewer pipe and basement settings, since meters were only set in basements where the latter were in good condition and gave promise of being free from frost. In the older sections of the city where the service pipes were near the surface, the sewer pipe settings were almost universal.

Unmetered services also froze in large numbers in the same sections of the city in which the metered services froze in largest numbers. Still, after all allowances are made, we believe that there were two defects in the sewer pipe setting which are now being remedied as fast as possible, as indicated in the accompanying cut, as follows:

First, the wooden meter cover did not fit tightly enough; indeed, it often became tilted as it rested loosely upon the meter. We are now substituting throughout the city a wooden rim (diagram) tightly caulked by oakum against the sewer pipe (A). Attached to the rim, which is about 1 in. thick, is a larger hinge, which is also attached to an inner wooden cover that comes down to the opening of the wooden rim on a bevel, and fits so tightly as to give promise of being almost air tight. This wood is being subjected to a chemical treatment that will preserve it. This wooden cover is only 1 ft. below the iron cover, and cannot be left up against the sewer pipe or the iron cover, so that the meter reader will be obliged to put the wooden cover in proper position before leaving the premises. In some sections of the city where there is most danger of freezing an extra foot of sewer pipe is to be placed underneath the 4 ft. that we now have, and a cross brace of wood is to be used part way down the riser to keep everything in place.

*Illustrated in Engineering News of Oct. 22, 1903.

The thawing of services was mostly done by four electrical machines. Three of them obtained their current from the street railways, at a cost of 6 cts. per KW., or $39.18 for the 434½ hours in which current was actually used. This current was of 300 amperes and 5 volts, or a total of 1.5 KW. per hour. In cases where the wires, nearly 1,000 ft. long, could not reach from the trolley to the meter we used a steam machine to furnish power to the dynamos. This machine of 12 HP. had just been purchased for other uses of the water department and was easily transported on wheels. The total cost to the department of repairing meters and thawing out the services has been $11,520, or about 46 cts. per meter, if distributed equally over the 25,000 meters in place. Of this sum about $3,500 has been required for inspection, taking out frozen meters, or those where only the service was frozen, repairing the meters either in place or at the shop, and resetting them. The machines thawed out 1,164 metered services and 349 unmetered, or a total of 1,513, at a cost of about $7,700, or about $5 per service. Private plumbers thawed out a few metered services, and many more unmetered ones.

COST OF SETTING.

The accompanying table will give the cost of labor and material in the three kinds of settings in 1903, and the estimated cost of the improved sewer pipe setting in 1904. The labor cost is high in basement settings, because the basement meters are widely scattered. In brick vaults the labor cost is low per meter because in such vaults two or more small meters are sometimes set in one vault. This table refers only to ⅝-in. meters.

COST OF SETTING METERS IN CLEVELAND, O.

Cost of Basement Settings.

Brick	$0.12
Cement	.05
Cover	.30
Fittings	.25
Total material	.72
Labor	3.23
Total	$3.95

Brick Vaults.

350 brick	$2.45
1½ sacks cement	.38
2 Couplings	.08
2 ells	.12
1 nipple	.06
1 union	.24
1 ring and cover	3.21
Total material	6.54
Labor	2.92
Total	$9.46

Sewer Pipe Settings.

	1903.	Estimated cost, 1904.
Sewer pipe	$1.46	$1.84
Frost cover	.18	.47
Cross brace	.00	.04
Ring and cover	1.42	1.42
2 ells	.12	.12
2 couplings	.08	.08
7' of ¾" pipe	.35	.35
Total material	$3.61	$4.32
Labor	4.01	4.51
Total	$7.62	$8.83

The average cost of setting 13,407 ⅝-in. meters set in 1903 was $6.87, and the meter itself, with connections, cost $6.50, or a total of $13.37. During that year 857 ⅝-in. meters were set in brick vaults, 3,174 in basements, and 9,378 in sewer pipe.

COST OF OPERATION.

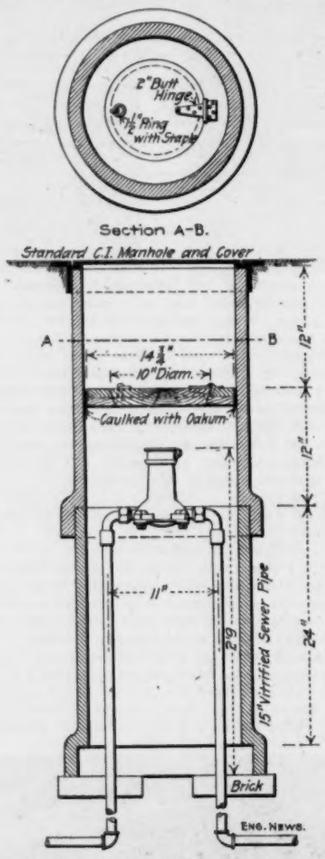
The cost of operation of the meter department is greater in this period of rapid setting and growth than it will be later. Nearly all the expenses of investigation of where to set new meters, and the clerical work connected with the setting, changes in the form of setting, and experiments connected therewith, are charged to operation. Many more meter readers are now employed in proportion to the number of meters in place than will be needed later. It has thus far been customary to employ one meter reader for every 1,000 meters in place, and to have these men not only read the meters every six weeks from March 1 to Dec. 1, but also to investigate all causes of waste and to notify the property owners and tenants of the same and direct them how to lessen the waste. It is also customary at every meter reading for a laborer to accompany the meter reader and to turn off the water in any house which is apparently wasting water, while the meter reader waits at the meter to detect any running water. We have hitherto bought none but Trident meters, of which we secured 10,000 ⅝-in., 800 ¾-in. and 200 1-in. meters, previous to last year, and 15,000 ⅝-in. last year. In each case this company was the lowest bidder, and we have found the meters very satisfactory, but have thought it well to frequently test them, to make sure that they were running all right. As time goes on it will not be necessary to do this so often, or to read the meters so frequently.

Last year the meter reading and clerical work connected therewith amounted to $1.10 for each of the average number of meters in use during that year, while the repairs were 10 cts. Interest and depreciation at 8% would be $1.07, or a total of $2.27.

On these small meters the increase in cost is more than counterbalanced by the difference between the pumpage expenses and what they would have been if the pumpage had increased as rapidly the past three years as it had been doing previous to the introduction of meters on a large scale. There remains from meters the large saving in the fact that the city has not been obliged to put in new pumps, buildings for the same, and large mains, which otherwise would have been necessary. Even if contracts for these had been let two years ago, they would not have been ready to enable the city to be supplied this spring with pure water from our new intake and therefore the typhoid fever epidemic would doubtless still have been at its height.

RESULTS TO THE CONSUMER.

It is too early in the history of the domestic meters in Cleveland to determine the results to the consumer. At



1904 Standard Setting for Water Meters, Cleveland, O.

the semi-annual collection last October only 8% of the entire number of houses metered paid more than under the assessment rate. Two-thirds of 1% paid the same, and the other 92% paid less. Twenty-four streets were selected with a good class of houses where nearly every home had been metered for over a year. On these streets having an average annual assessment of $11.83, the 825 families were paying under our system of minimum charges $7.36 or 62% of their old assessment rate, and they were using only $3.95 worth of water per year, or 33% of their old rate; that is, they were using on the average only 9,875 ft. per family per year, or 202 gallons per day. On a class of houses considerably poorer on eight streets were 172 residences, the average assessment rate being $7.64 per year, and the payments under the present minimums are $5.38, or 70% of this, and they are using on the average only $2.61 worth of water, or 6,525 ft. per year. This is equivalent to only 134 gallons per day per family.

Finally the 648 metered places on 23 still poorer streets have been investigated for the year ending April 1. Their annual assessment averaged only $6.14. They are now paying $4.66, or 76% of the above, and are using an average of only $2.32 per year, or 5,800 ft. This is equivalent to only 120 gallons per day per family, or probably only 25 to 30 gallons per capita. The better class of houses would only pay 33% of the assessment rates if there were no minimum, the next poorer class of houses would pay 34%, and the still poorer would pay 38%.

USE BY SCHOOLS.

The use of water in the parochial schools, both Lutheran and Catholic, has been ascertained for they have been paying meter rates metered. It is proposed henceforth to allow free to those and to the public schools some limited amount of water per pupil per day of scho[illegible]ndance, and charge both public and private schools a[illegible]ress of this amount. During the approximately 14[illegible] of actual sessions of the schools during the six [illegible]ths ending April 1, 1,753 pupils in average attend[illegible]en the five Lutheran schools used 3.5 gallons per day [illegible]upil. Similarly the 14,130 children in average a[illegible]nce in the thirty-four Catholic schools used 3.9 g[illegible]. In each case, however, there were buildings w[illegible] over three times this average amount was used, e[illegible]though metered. In fact, there was one building [illegible] used eight times this average, while many others u[illegible]r less than the above average of under four gallons [illegible]day.

MINIMUM RATES.

The minimums that were adopted with t[illegible]eginning of universal metering in 1902 were as follow[illegible]

Five dollars semi-annually for all meters larger than ⅝-in., unless meters had been put in by the consumer when the minimum was $4. In the case of the ⅝-in. meters there are four minimum rates; $1.25 every six months for all semi-annual assessment rates of $2 or less; $2 for those whose assessment rates are $3 or less, $3 for those whose assessment rates are $5 or less, and $4 for all others. There were two reasons for these minimum rates; one to prevent too great a reduction in revenue in a city which gives the small consumer the same low rates as are paid by the United States Steel Company with its water bill of $30,000 a year; the other reason was to meet the objection of those who feared that without a minimum people would economize unduly in the use of water. Even the lowest minimum at our rates allows the use of 130 gallons per day, or sufficient to flush a water closet 20 times a day, to flush, 200 ft. of ¾-in. pipe from the street main to the kitchen three times, and to allow 56 pint glasses per day for drinking, and 42 gallons for cleaning.

The time, however, has now arrived where the financial condition of the department permits the abolition of all the minimums, except the lowest of $1.25 every six months, which should be retained to insure a healthful use of water, and because it costs fully that amount to take care of the meter and to provide for interest and depreciation on it, even if not a drop of water goes through it.

An ordinance is now pending in the City Council to abolish all other minimums on the ⅝-in. meter.

EFFECT ON REVENUES.

Thanks to the growth of the city in business and population the reduction in charges to the residences that have received meters has been somewhat more than counterbalanced by the increased consumption of water by large business places and by the increased population. During the six months ending with September 30, 1900, the collections were $371,000. During the corresponding period this year they will be about $420,000, but if all the minimums, except the lowest are swept away, which would take effect with the October bills, the revenue during next winter will probably be about the same as four years before, while the majority of household consumers will pay only one-third as much as formerly.

The wages and salaries in the Meter Department are as follows:

A chief at	$2,000.00
A bookkeeper at	1,100.00
A few clerks at	660.00 to 900.00
Foreman and inspectors at	30 to 42 cts. per hour.
Meter readers at	2.25 per day.
Installers at	2.20 " "
Laborers at	1.68 " "

Eight hours constitutes a day's labor.

CONCLUSION.

Despite the difficulties of the past winter the meter system is very popular with the mass of the people. During the first half of May preceding the time when this paper is sent to the printers, the requests for meters have averaged more than ten a day, Sunday included. Meters are set and cared for entirely at the expense of the Water Department. The early opposition of the plumbers to this work of direct city labor has practically disappeared. The department is just undertaking a systematic lowering of all services throughout the city where they are not 5½ ft. below the surface and located on streets where there is special danger of freezing. A few street mains are being lowered also, although none of them froze last winter. The press of the city is friendly, and the Mayor and Board of Public Service are very enthusiastic for the metering of every connection. It is probable that this year every connection larger than ⅝-in. and half of all the others will be metered. Only 465 services larger than ⅝-in., including free connections, but not free lines, are still unmetered, and the Council has just authorized the purchase of $12,000 worth of large meters with which all of these services will be metered this year. If support is received from the Council, all the remaining services will be metered within three years. What has been done already, however, renders it certain that even if the pace hereafter is slower, the time is not far distant when universal metering will be accomplished in this city of 450,000 inhabitants, which already has more meters than any other city in the United States, excepting New York and Milwaukee, and more meters on domestic consumers, probably, than even New York, although still a little behind Milwaukee in this respect.

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